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EDITORIAL.

With the first number of a new volume, we present our readers with two articles on subjects of general importance.

The first develops a distinction between the large fundamental muscles that move the large joints, that unfold first and represent to some extent motions which man has in common with the higher animals, are the last to be affected in all degenerative motor diseases on the one hand and on the other, the smaller muscles of face, fingers, articulation apparatus, which are called peripheral or accessory, develop later, and are functionally superposed upon the more central system, are quite liable to be involved in school-bred automatisms and chorea, represent finer, more rapid, specialized and exact movements, and whose changing tensions are very closely connected with thought and all psychic activities.

Mr. Burk has for the first time pointed out the relation of this distinction to Flechsig's recent differentiation between the projective system and the "association fibres" of the brain, both ends of which are in the cranium, and which connect areas of the posterior and especially frontal areas, to the possible functions of Vulpius' transverse fibres of the middle layer, and also to the higher and third level of Hughlings Jackson. He then proceeds to state the pedagogic implications of this view point. (P. 20.)

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Selecting the hand, and leaving speech development for later and more detailed treatment, he shows how recent research gives it a far higher function than had hitherto been conceded, as the best index of intellectual power, and traces in some detail and with much recent new matter, its evolution from a foot as coincident with that of intelligence, and by implication its importance in education. On the whole, the article summarizes and brings into new and very suggestive relations to each other and to school work and educational philosophy generally, a great variety of special investigation not readily accessible.

In the article on Inhibition, the author briefly indicates the views of Herbart, Benecke, Taine, Roux and others who have studied the problem of the arrest of one function by another which absorbs more than its share of energy, and undertakes to explain restlessness. Suggestive as the article is, it only opens to others a glimpse into a far vaster and unexplored realm, further treatment of which may be expected in these pages.

Dr. Lukens, who had been connected with Clark University for several years, spent the last academic year travelling in Europe, with the purpose of seeing as many educational institutions and men of different countries prominent in pedagogical work as possible. At the editor's request he has jotted down, very informally, some of his observations, and expressed with great frankness his impression of men, opinions, and methods in a way sure to be helpful.

Many reviews and book notes are crowded out and will appear in the next number.

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FROM FUNDAMENTAL TO ACCESSORY IN THE DEVELOPMENT OF THE NERVOUS SYSTEM AND OF MOVEMENTS.

By FREDERIC BURK, Fellow in Clark University.

Two tendencies in educational method have ever struggled in greater or less opposition—one based upon the logical divisions of the subject studied ; the other based upon some theory of internal order of development in the mentality of the pupil. Theoretic pedagogy has made the latter tendency its contention. Commenius, Rousseau, Froebel and others have gained the title of "reformer" essentially because they attempted to break away from a form of education determined by the logical order of subject-matter and sought to substitute for it some theory of the psychological development of the pupil as the regulative principle. It is not until the question is brought under close scrutiny of experience or of theory, that the possibility of an essential difference between the logical order of subject-matter and the pedagogical order of mental development presents itself in any convincing way.

To illustrate: in learning to read, the logical order naturally shows us that sentences are made up of words, words of syllables, and syllables of letters ; it would seem that letters being the ultimate logical simples would also be the ultimate pedagogical simples and the point of beginning for the learner. Such, indeed, was the method employed in schools universally until very recent times, and it still is widely used in some countries. But experience has shown conclusively, nevertheless, that in this matter at least, the avenue of least resistance is not upon the lines of logical cleavage, but on the contrary, it has been found that children learn to read far more readily by beginning with words or even sentences. Thus, in this case, the pedagogical order is almost the reverse of the logical order. In certain other forms of instruction, experience has as definitely established a conflict between the pedagogical development of pupil and logical order of subject which makes it doubtful that the latter is as serviceable for educational purposes as practice has often assumed.

The educational reformers —some by theoretic deductions and others by experience or by happy intuition—have attempted

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to bring into clearer light a subjective order in the development of mentality. Froebel, Herbart and many others certainly have made many valuable contributions which have stood tests of experience. But we have as yet no general basis in positive science for such an order; and it would seem natural that the modern biological sciences—particularly neurology and experimental psychology—should make contributions to this problem. For the purpose of bringing together in convenient form such scattered facts in these sciences as bear directly or indirectly upon the problem, this study has been undertaken. The first chapter will review the contributions in the field of recent studies of the nervous system; the second chapter will trace the development of the human hand and attempt to correlate this development with that of the nervous system. A third will review studies upon the growth of hand motility during the school ages.

Suggestions from the Development of the Nervous System.

It was but natural, in the early attempts to find a relation between the various structures of the nervous system and the different degrees of mentality observable in masses of individuals, that attention should have first been turned upon the grosser forms of brain anatomy—the shape and protuberances of the skull, arrangement of the convolutions, the size and weight of the brain, etc. Each of these features has been subjected to scrutinizing comparative study. Practically nothing, however, of psychological significance has thus far been obtained from any of these studies, except to render it more doubtful that any significant relation exists between these gross differences which naked eye or scales may detect, and the differences of mentality in individuals. Large differences in weight, for example, are shown to depend chiefly upon variations in the amount of non-nervous material—the supporting tissues, blood vessels, fluids, and the fatty protecting sheaths encasing nerve fibres. Recent investigation has been gravitating toward a solution in the finer microscopical structures of nervous tissue. While as yet the interpretation of facts in this field is more or less doubtful, nevertheless certain features are suggestive to psychology and education.

Growth of the Brain in Weight. For the sake of completeness it may be well to mention in passing the result of recent inquiries into the periods of brain growth as determined by weight. Vierordt from records of 415 males and 424 females, ranging to 25 years of age, finds that maturity in weight is practically complete at about the eighth or ninth year. The period of most rapid increase after birth, according to this in-

vestigation is from birth to four years of age. Mies[1] places the average weight of brains of new born males at 340 grammes and of females at 330. At maturity he calculates the average as 1,400 grammes for males and 1,050 grammes for females. The period of most rapid growth is that of the first nine months of life, during which one-third of the whole increase after birth is added. The second third of the whole increase is added between the ninth month and the twenty-seventh month. The remaining third is slowly obtained. Mies says maturity of weight is reached sometime between twenty and thirty years. Pfister,[2] in a study of 156 brains from birth to the fourteenth year, confirms in a general way the rate of growth as found by Mies, and his figures would indicate that the maximum weight is practically reached in the pubertal years.

While the data, from incompleteness and questionable accuracy, will not allow us to determine with absolute precision when growth matures, we may nevertheless safely conclude that the rate, rapid in embryonic life and infancy, steadily decreases; and that, in all probability, no large increment of weight is added after the ninth or tenth years.

Growth in the Cell Body and its Processes. The process of division by which new cells are created ceases in the embryonic period, as commonly stated, by the fifth month of fœtal life. Reflection upon this fact has left a fatalistic flavor in the conclusions of many, for it seems to limit the possibilities of education. However, since the number of cells thus created reaches the billions and there is evidence of what seems millions of undeveloped cells in the brains of men in their old age, it would appear that our present stock of possibilities are by no means exhausted. The nervous matter at any age shows what seems to be stages in growth of cell body, and along with the developed cells are to be found small cells, which neurologists have generally considered an undeveloped form awaiting structure or function, education or impulse, or whatever else the inciting cause may be, to call them into active service. Kaiser[3] took similar sections of the cervical region spinal cord in a new born child, a boy of 15 years and an adult. The number of developed cells in the new born child was 104,270; in the youth, 211,800; and in the adult, 221,200. The number of cells which came into function during the first fifteen years of life was therefore double the number at birth. From this observation it would seem, that even in the spinal system, the earliest to

[1] Ueber das Gehirngewicht neugeborner Kinder. Wiener Klin. Wockensch., 1889, p. 34.

[2] Das Hirngewicht in Kindesalter, Archiv. f. Kinderheilkunde, 1897, pp. 164–192.

[3] Die Funktionen der Ganglienzellen des Halsmark, 1891.

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mature, growth of new powers is significantly active throughout, until the adult period at least. Vignal[1] finds that the cells of the fœtus are distinctly smaller than those of the child and that they are more closely packed together. There is much indirect evidence for the conclusion that the cell bodies are increasing in size, though doubtless by such small increments as to elude observation by the methods employed, throughout the greater portion of adult life. Ramon y Cajal[2] has attempted to establish the principle that the size of a cell depends upon the number of its processes and collateral branches, that is, upon the number of other cells with which it is associated. Cajal has also offered the plausible theory that the growth energy which in early embryonic life is employed in cell division, passes, when this process ceases, into the work of forming the finer cell processes and collaterals and continues operative until senescence sets in, *i. e.*, to the number of other cells with which it is functionally associated.[3] There is also scattered evidence to indicate that the cell changes in chemical constituency with age. Dr. C. F. Hodge,[4] from a study of old and young honey bees and of the cells of a fœtus, a middle-aged man and a man of 92 years, concludes that there are changes of some character shown by difference in chemical reaction. Bearing upon this point Donaldson in his resumé of fatigue says: "In childhood the amount of stored material is small, large in maturity, and small again in old age. Hence the cells would by reason of this fact have the greatest capabilities for work in the middle period. Between childhood and old age there is, however, this difference, that while in the former the non-available substances in the cell are developing, not yet having material, those in the latter may become incapable of reconstruction."[5]

Growth of Finer Microscopic Fibres. It is a speculation to which neurological theories point, that the fibres which connect different parts of the cortex, one with the other, are most likely to be concerned in some way with association and the higher forms of neuroses. As early as 1840, Remak made a study of these "tangential" fibres and concluded that no material growth of these fibres took place beyond the eighth or tenth

[1] Development des Elements du Systeme Nerveus, 1889.
[2] Archiv. f. Anatomie, 1896, p. 191.
[3] Studies bearing upon this question will be found in Vignal's Développment des ëlements du System nerveux cérébro-spinal, Paris, 1889; Krohn, Jour. Mental and Nervous Diseases, 1892; Donaldson, Growth of the Brain, pp. 237–240, gives a resumé together with a cut reproduced from Vignal showing comparative sections of cortex from fœtus, child at birth and adult.
[4] Jour. Phys., Vol. XVII, p. 130.
[5] Growth of Brain, p. 314.

year. Exner, in 1881, and Tuczek later, made some study of the problem, and Fuchs found from 33 brains, confining himself to a single area in the posterior central gyrus, that in the outer layer of the cortex some tangential fibres appeared as early as the fifth fœtal month, and later in the lower layers. He thought the fibres reached their maximal number and size in the seventh or eighth year. Obersteiner much later reaches the same conclusion. In 1892 Dr. Oscar Vulpius,[1] of Heidelberg, made a more thorough and careful study from 22 brains distributed in age as follows: 32d fœtal week, 34th fœtal week, birth, 4½ months, 8 months, 11 months, 16 months, and 1¾, 2¼, 3, 7, 10, 16, 17, 33, 79 years. He cut homologous sections from the first frontal gyrus (left), third frontal gyrus (left), third frontal gyrus (right), anterior central gyrus (right), occipital lobe (right), and first temporal gyrus (left). After preparing and staining sections, he counted the tangential fibres in an area of a given size as they occurred in three layers of the cortex. The more important conclusions reached by Dr. Vulpius are that the tangential fibres begin in the outer and inner layer about the fifth month, and in the middle layer about the ninth month, that this growth does not cease in childhood, and that as late as the 17th year the increase of tangential fibres is marked; in old age an apparent decrease in number takes place; the greatest number of tangential fibres is to be found in the central motor region; poor nutrition seems to inhibit the growth of tangential fibres. Some of his results, as shown by charts, might be stated as follows: the inner layer in all localities and practically all ages has far the most tangential fibres and the middle layer the least; the relative number of fibres in each layer varies widely in each area, those of the central or motor region having the greatest number; the fibres of the inner layer develop their sheaths in all cases earlier, and in the motor sight and hearing regions, almost reach their maximum in number during the second year, while in the speech and other centers, there is a gradual increase until the eleventh year and a later gradual increment until the 33d year at least; the outer layer fibres follow in general the course of growth of the inner layer, but contain generally from one-eighth to one-half as many; the middle layer in no case makes an appreciable increase until puberty, grows most rapidly in the early adult years, and never contains more than a third as many fibres as the inner layer.

Kaes, in 1893, by a comparative examination somewhat similar to that of Vulpius, shows so conclusively that the development of fibres in the cortex, especially the tangential, is a

[1] Archiv. f. Psychiat. u. Nervenkrank, Vol. XXIII, 1892.

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process still in active progress as late as the 39th year, that Edinger, who in earlier editions of his "Nervose Central Organ" denied the demonstration of this, admits in his latest edition (1896) that the principle has been established. In a later study, Kaes comes to the conclusion that at 40 years of age there is at least a partial arrest in the rapidity of growth of these fibres. The small number of brains compared, however, makes this statement of little value.

Dr. Hamarberg, unfortunately cut short by death in the midst of a most promising comparative study of normal and idiot brains, nevertheless made a definite contribution.[1] He compared homologous sections from the brains of nine persons ranging in degree with similar sections from normal brains, comparing the size, number and characteristics of the cells. In all cases the brains of defectives showed marked deficiencies. The developed cells were far fewer in number and of irregular and retarded development. His study leads to the conclusion that the idiot brain is one which has suffered arrest of development in some particular, involving larger or smaller areas of the brain, at some early period.

The more recent studies by Kaes upon fibre development entirely corroborate this conclusion of Hamarberg. In a recent contribution[2] he states conclusions from a detailed comparison he has made upon three brains; that of those of normal child 15 months old, a microcephalous idiot of 18 months, and a macrocephalic dwarf 25 years of age. The dwarf was the size of a child of about nine years of age, unable to speak or to understand language, and hampered by dragging movements of the limbs. Dr. Kaes measured the thickness of different layers of the cortex in several corresponding parts of these brains and gives interesting tabular results. He concludes that in development of the cortex the dwarf of twenty-five years of age has not advanced beyond that of the normal child of 15 months. The projection fibres of the central convolutions are better developed in the normal infant than in the dwarf, while the associational fibres which connect convolutions, marked in the normal infant, are absent in the dwarf. A feature that is common to both idiot brains is the manifest arrest by development of the second and third (Meynert) layers, and Dr. Kaes, from this and previous observations which he has made, feels justified in asserting that the development of this cortical region is essential to psychic unfoldment. A singular anomaly however is, that the external

[1] Studien über Klinik u. Pathologie der Idiotie nebst Untersuchungen über den Normalen Bau der Hirnrinde, 1890.

[2] Ueber den Markfasergehalt der Hirnrinde bei Pathologischen Gehirn. Deutsch W'chschr., Nos. 10 and 11, 1898.

tangential layer is broader and better developed in the idiots, than even in adult normal brains. He offers as a possible explanation the biologic fact that in the lower animal series this layer is larger, comparatively, than in the higher animals, and that in man it frequently appears only in rudimentary form. This external layer develops as low down the scale as reptiles, even prior to the projection system, and Dr. Kaes holds the opinion that we must consider it the precursor or oldest form, on the sensory side, of the projection system. Applied as an explanation of the anomaly described, Dr. Kaes takes the view that these idiots are arrested in development at an early biologic stage and the relatively large amount of tangential fibres represents persistence of an old type. Further he finds that the microcephalous infant had suffered a complete arrest of the development of the fibres of the central convolutions while those fibres most directly in connection with smell were retarded the least, which is significant in view of Edinger's evidence that the apparatus of smell is the oldest of cortical structures, appearing even in reptiles.

This theory of origin regarding the outer tangential layer, put forth by Kaes, agrees neatly with that of the school of Ramon y Cajal which has contended that sensory impulses are received in cortical cells by way of the dendritic processes extending upward to this layer.

Speculatively regarding the two theories, we might say that the external layer is the older path but that in more highly evolved forms some new avenue of approach has been established; that idiots tend to revert to this more ancient path which functions only a low order of psychosis.

While this class of studies, dealing with the growth of the finer microscopical nervous structures in later life, is not as numerously represented as could be desired, yet the results seem sufficient to establish the fact that the finer nervous structures continue to grow until a late period of life; and further, that there is some definite order in their progressive development. These conclusions, when worked out in more accurate detail, will serve to banish many of the fatalistic inferences which psychologists have been prone to conclude from neurology, and to extend the limits and importance of education.

The Order of Functional Maturity. The conclusion has now passed into general acceptance that when a nerve fibre acquires its fatty sheath, or becomes medullated as is said, it is then functionally mature. No nervous function is ascribed to the sheath. It serves the same purpose, it is believed, that rubber covering serves for electric wires—it prevents wasteful radiation of the nerve current.

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The significance of medullation, once established, becomes a key of great value in determining the order in which the various parts of the nervous system develop. Studies in this direction have been pursued most notably by Professor Flechsig, the psychiatrist of Leipzig. His investigation upon the order of development in the parts of the spinal chord was published as early as 1876 and a continuation of this line of investigation in the brain has appeared in very recent monographs.[1] The spinal chord consists of a core of gray matter surrounded by vertical bundles of nerve fibres. These various bundles connect different portions of the nervous system.

Flechsig found that the class of nerve fibres first to take on their medullary sheaths are those connecting neighboring centers in the cord, and those concerned in receiving and discharging simple reflex reactions. This medullation process begins in the latter half of the fifth fœtal month. Then follows the medullation of the short columns connecting different levels of the cord, and presumably, therefore, concerned in local reactions of the cord itself. The columns of Burdach follow, and still later that of Goll, which conveys the sensory impulses, received chiefly from the periphery, upward to nuclei in the medulla and are thence transmitted to the cortex ; still later the cerebellar columns conveying impressions to the cerebellum, having to do with equilibration, are developed. The pyramidal columns which discharge voluntary impulses from the cortex of the brain downwards do not mature in the cord until about the time of birth and later. This order of development of the spinal columns is of important significance to the problem in hand, for it shows that the order in which the different strands of the spinal cord reach maturity is the order of racial unfoldment. The simple reflex mechanism is the earliest in biologic development of the nervous system, and, as shown, is the first to mature in the development of the individual. Voluntary movements regulated by the cortex are the most recent in racial development, and, the pyramidal tracts which convey these impulses, are the last of the spinal columns to reach maturity. We have here, therefore, the illustration of the principle that in the development of human nervous functions, the first mechanisms to mature are those which are fundamental and racially the oldest, and that the order of development proceeds from these to those which are of more recent evolution.

The spinal cord of the human infant at birth, Flechsig finds, is completely medullated with the exception of the pyramidal (motor) columns. Medullation extends to some extent in the

[1] Gehirn und Seele, 1896 : Die Localization der Geistigen. Voränge inbesondere den Sinnesempfindungen, 1896.

medulla oblongata and in the pons, but the entire cerebral hemispheres are yet immature with the exception of a few traces in the internal and external capsules and in the lenticular nucleus. The new-born human infant is therefore a creature not unlike Goltz's dog whose cerebral hemispheres were extirpated. This dog, it will be remembered could react, by means of his spinal mechanisms, to external excitations of pressure, light, sound, etc., but was utterly incapable of originating movements or of profiting by memory.

Flechsig's most recent studies have attempted by the same neurological method, to trace the order of development of the various bundles of fibres in the brain proper. In the monograph *Die Localization der Geistigen Vorgänge inbesondere der Sinnesempfindungen* (1896), he gives the results of his researches upon the sheaf of sensory fibres which, originating (indirectly) in the spinal cord, conveys impressions through the internal capsule to the cortex. He finds that it is composed of three separate bundles, each maturing at a different period. The first bundle begins to mature just before birth. The largest portion of its fibres go directly upward and distribute themselves over the two central convolutions. This is a fact of extremely important significance in substantiation of the evolutionary principle. Of all localization of the brain, that of these convolutions is most clearly established in detail. They represent the older fundamental parts of the organism — kinæsthetic and tactual sensation of the arms, legs, trunk and of bodily feeling generally. The region they enter is the one which, on the motor side, controls the most essential and chief movements of the body, as the electrical experiments of Ferrier, Horsley and others upon monkeys have demonstrated. A small branch of this first system disappears in the direction of the occipital (visual) area, but Flechsig is unable to assert positively that this branch contains optic fibres. In the first month after birth a second bundle of this sensory sheaf, appearing in the inner capsule from the lower levels, matures in the direction of the cortex. A large part of these fibres find their destination in the same areas as those of the first, while another part turns inward and distribute themselves along nearly the whole length of the gyrus fornicatus on the mesial side. According to Ireland,[1] resting his conclusion on the experiments of Ferrier, Horsley, and Shäfer, this region represents sensations of touch and temperature, but its exact function is yet doubtful. The third of these sensory bundles does not mature until a very much later period, varying from one to several months after birth. One part goes directly to the foot of the

[1] Journal of M. S., Jan., 1898.

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third frontal convolution (the Broca center for speech). Other smaller bundles are distributed to the first and second and third convolutions and also to the gyrus fornicatus. The most significant feature is that Broca's speech convolution begins development at a very much later period than other parts of the great areas concerned in general bodily movements. The order of development of the fibres in their approach to the cortex through the internal capsule is regulated by the same principle, we therefore see, as those in the spinal cord — those which perform the oldest and most general functions mature earliest.

The first of the special sense centers in the cortex to mature, according to Flechsig, is that of smell, which, according to Endinger's studies, is the first sense center to be evolved in the biologic scale, appearing as low as reptiles; the last to mature is that of hearing. The process of medullation of the fibres leading to and from the sense centers takes place rapidly, and by the end of the first month of human life, all of them show some evidences of maturity.

Up to this point Flechsig's anatomical contributions are accepted generally and much that he has put forth on these lines has been corroborated by other neurologists. But in the matter of the fibre connections of the cortex with lower nervous centers, he offers a revolutionizing contention in brain localization and his claim is now under the fire of criticism and dispute. Heretofore it has been the accepted theory that the entire cortical area sent or received fibres to and from the lower centers. Flechsig, from his examination of infants' brains, declares this is not true. Only about one-third of the cortical area at the end of the first month shows these descending or ascending fibres. Then medullation begins to appear in the other areas, in the frontal portion, in the large posterior parietal area and in the Island of Reil, covering in all two-thirds of the human cortex. But contrary to expectation, based upon the supposition of previous methods of determination, these medullated fibres do not come nor go from the lower brain centers. They give no evidence of a peripheral source or destination. They do not follow the course of the fibres developed in the first month of life. On the contrary, Flechsig contends, the source and destination of medullated fibres of these larger cortical areas are in the sense centers previously developed — those of sight, hearing, touch, smell and taste. Since they are of different anatomical connection and direction, the conclusion is necessary that they must have a different function. Flechsig leaves his anatomy at this point to offer the plausible speculation that these large centers have for their function the association, and the superior directive power of inhibitive interference upon the areas of sense impressions. "Only one-third of

the human cortex," he concludes with some pardonable eloquence, "stands in direct relation with the processes which bring sense impressions to consciousness and excite the muscles and mechanism of movement; two-thirds have directly with these nothing whatever to do. They have another, a higher function" — the function of knowledge, of interpreting experience, of the æsthetic sentiments, of the scientific decisions, of the moral judgments, etc. Through disease of these highest association areas, if we may follow Flechsig in some daring speculation, the individual is thrown back for the determination of his conduct upon the sense or lower centers. Such, he suggests, is the effect of alcoholic intoxication, and other more permanent forms of mania. It is undisputed that in idiots and imbeciles, Flechsig's areas of association are notably small. Flechsig goes further and claims upon anatomical evidence that in monkeys instead of two-thirds of the cortex being devoted to these associations, there is but one-half; among carnivora, these centers are very small and decrease as we descend the scale of mammals, disappearing entirely in rodents. It might be well, since Flechsig's conclusions are now being tested by criticism, to draw a line between his anatomical contributions and his speculations. Unquestionably he has conclusively shown that certain bundles of fibres, representing certain more or less specific movements, mature at distinctly different periods. Regarding his association centers, it must be admitted that Flechsig has here contributed positive data of anatomical observation that the sense centers are indirectly associated in a common area. As positive data, it cannot be contradicted by theory or mere argument — we must wait for positive data of contradiction.

Dr. Ross in his *Diseases of the Nervous System* was perhaps the first to attempt a distinction in the nervous system between structures which in function antedate the human form of the organism and those which have been added during the period of human evolution. He says: "The portions of the nervous system which man possesses in common with lower animals and which are well developed in the human embryo of nine months, I shall call the *fundamental* part, and the portions which have been superadded in the course of evolution, which differentiate the nervous system of man from that of the highest of the lower animals, and which are either absent in the human embryo or exist only in an embryonic condition, I shall call the *accessory* part of the nervous system." Dr. Ross points out that the main movements which distinguish man from the lower animals are those which he has acquired since he adopted the erect posture—the varied movements of the hand in prehension and tool-using which developed after the

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hand ceased to be merely a foot; the movements of articulatory organs concerned in speech, and movements of facial expression. Dr. Ross, by this suggestive juxtaposition of fundamental and accessory physical parts in the human organism, with the fundamental and accessory mental powers of man, has opened a field of inquiry rich in suggestion for psychology and education. Are these accessory movements of the hand and the articulatory organs, in some intimate connection with that mentality of man considered as accessory developments to those of the lower primates? Have these accessory elements, by virtue of their comparative newness, more instability and plasticity, and are they therefore more subject to education? Lastly, and most important in the development of the individual, is the order the same as that of the race, so that from infancy to manhood we have a procession of developing parts beginning with the oldest and most fundamental and ending with the newer and accessory? Granting, for example, that the physical development follows this order, does mentality as well? If so, and if we can follow this order of development in some detail, we should have a principle that long has been needed for clearer visualized thinking in psychological and educational science.

We must not neglect in this very brief consideration the very probable theory, happily named by Baldwin[1] the "short-cut" theory, by which development in individual man, by ages of modification, cuts across lots, thus escaping many needless bends and turns in the road evolution has actually travelled. Unless we accept this modification it would be impossible to explain many anomalies; for example, the fact which Gratiolet has pointed out that, while in the embryonic development of the ape, the tempero sphenoidal convolutions (embracing the human auditory center) appears first and the frontal convolutions last, in man the order is reversed.

Man does not complete his fundamental development at birth. If we are to accept Flechsig's association areas as the centers of human reason, we find these parts, anatomically, far down the vertebrate scale. From an objective study of human activity as illustrated by movements, the suggestion would be that these accessory structures are delicate modifications of existing structures,—new duties added to old forces. Ross thinks we have indirect evidence of these accessory formations in the huge development of the prefrontal lobes, which have pushed the posterior parts of the brain over the cerebellum, made the Rolandic fissure seem further back, relatively, and forced the posterior limb of the Sylvian fissure into a more horizontal position.

[1] Mental Development in the Child and Race, p. 21.

Flechsig's contributions of data go far to enrich and substantiate the theory of Ross by showing an evolution in the order claimed. But Flechsig's facts deal wholly with infancy and must be taken merely as the beginning processes of development.

From the evidences of late growth of fibres shown by Kaes and Vulpius, and of cell bodies by Hamarberg, there is justice in assuming that these processes continue until late in life under regulation by the principle which requires the more general and fundamental structures to develop before the accessory. If this indeed be true, then it is clear that the historic pedagogical contention, stated in the preface, that the order of instruction should be regulated by the order of internal development of the mind, rather than by the logical order of the subject-matter studied, rests upon a substantial basis.

The Level Theory of the Nervous System. The conception of the nervous system as an undifferentiated unity, such as pervades the popular notion of mind, is not a view that finds substantiation by modern investigation. The notion that all our actions are dictated from a single center, the brain, is at best but half a truth; many actions which have every appearance of good sense are regulated entirely within the spinal column; and some from within the walls of the abdomen. The lower orders of animals have no brain ganglia, and the lowest vertebrates no cerebrum. Man epitomizes the products of biologic history, and from an evolutionary standpoint we should expect a nervous system of added parts instead of a homogeneous organ. All positive evidences from the sciences of anatomy and physiology, and pathological phenomena as well, go to support the evolutionary view of the nervous system of parts, correlated and closely associated, but nevertheless preserving a degree of relative independence.

It was some thirty years ago that Dr. Hughlings Jackson, the eminent English pathologist, made practical application of the evolutionary theory of the nervous system to the diagnosis and treatment of epilepsies and mental diseases. Such has been the practical success of this application, that the so-called Hughlings-Jackson three-level theory is now the established basis of English diagnosis, and, in the words of a reviewer,[1] it has established system where previously all was chaos.

Jackson conceived the nervous mechanism as composed of three systems arranged in the form of a hierarchy, one upon the other, the higher embracing the lower yet each preserving

[1] Dr. James Anderson in Hack Tuke's Dictionary of Psychological Medicine.

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for itself some degree of exclusive independence. The lowest level is composed of those cell structures which receive impulses without physiological break, from the periphery or non-nervous tissues and those which discharge impulses into such tissues to produce movement. This has also been called the reflex level for it represents the type of simplest reflex and involuntary movement. Jackson localized these structures in the grey matter of the spinal chord, medulla and pons. His second, or middle level, comprises those structures which receive sensory impulses, not from the periphery nor from the non-nervous tissue directly, but from cells of the lowest level; the motor cells of the middle level discharge, not into non-nervous tissue directly, but into the motor mechanisms of the lowest level. If we say that the lowest level "presents" impulses, then, in Jacksonian phraseology, the middle level "represents" them. Anatomically, Jackson included in the range of these middle level structures the cortex of the central convolutions, the basal ganglia and the centers of the special senses in the cortex. Evidence for such a level lies in the fact, now proven by the process of secondary degeneration of nerve fibres, that there are no fibres extending continuously from the periphery or muscalature to the cortex nor in the reverse direction. In all cases they extend as continuous fibres only to the vicinity of cells of the reflex level in the cord, medulla and pons, as Jackson held. Jackson's highest level, as the topmost layer of the hierarchy, bears the same relation to the middle level centers as the middle to those of the lowest level. He presumes upon no continuous connection between highest and lowest level—the middle level structures mediates between them as a system of relays. The highest level, therefore, "re-represents" the external world through the double mediation of the middle and lowest levels. Jackson had no anatomical evidence in positive proof of the actual existence of highest level structures. His ground for it was physiological and a conclusion necessary from practical diagnoses of epilepsies. He localized it by accepting Broadbent's hypothesis. Now it strangely so happens that Broadbent's[1] hypothesis forestalls, both in its localizations and assumed functions, Flechsig's "association centers." In function and localization, therefore, Jackson's highest level and Flechsig's alleged association centers are practically identical.

According to this hierarchal arrangement of the nervous system the lowest level, as the simplest, oldest, most fixed and non-plastic, contains mechanisms for the simple fundamental movements in reflexes and involuntary reactions. The middle

[1] For original article see Med. Chir. Trans., 1872, p. 178-9; Jackson's acceptance, Brain, 1879.

level regroups these simple movements by combinations and associations of cortical structures in wider, more complex mechanisms, producing a higher class of movements. The highest level unifies the whole nervous system, and, according to Jackson, is the anatomical basis of mind. "The highest level centers," says he, "are nothing else than the centers of universal and complex representation, or what is the same thing, universal and complete co-ordinations, or, using old-fashioned language, they are the whole organism."

Jackson's theory is thoroughly evolutionary in its essential conceptions. "What are the lowest levels," says Jackson, "are centers for the simplest movements of the limbs, which become evolved, in the highest centers, into the physical basis of volition. What in the lowest levels are centers for simple reflex action of the eyes and hands are evolved in the highest level, with the physical basis of tactual ideas. What are the lowest centers for movements of the tongue, palate, lips, etc., as employed in eating, swallowing, etc., are, in the highest centers, evolved into the physical basis of words, as symbols serving abstract reasoning, what are the lowest centers for circulatory, respiratory and digestive movements, in the highest centers, are the physical basis of the emotions. So to speak, the lowest level does menial work; the highest level, evolved out of it, becomes in great degree independent of it and is the anatomical basis of mind."

The three-level theory grew chiefly out of the need of a practical working hypothesis in the diagnosis of mental diseases, and as such it has proved serviceable in pathological practice. In epilepsies, due to affections of the lowest level, there are spasms of the reflex movements without necessarily involving higher and more complex co-ordinations, as, for example, respiratory fits. The middle level epilepsies are of a more complex order, originating in some point of the extreme periphery and extending in directions that are found to agree with adjacency of centers for these movements in the cortex; loss of consciousness is frequently a subsequent, but not necessary accompaniment. Jackson localized the seat of middle level epilepsies in the Rolandic convolutions, and so accurate was this conjecture, that in the light of subsequent studies in brain localization, trephining of the skull and removal of the diseased portions of the brain has become a successful mode of treatment. In 1895 Starr[1] reports 350 cases of trephining with a large percentage of successful results. Laurient earlier reports upon 102 cases of trephining for middle level epilepsy as follows: cured, 54; improved, 20; not improved, 17; made worse, 2; died, 7.

[1] Brain Surgery.

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Very different, however, are the forms of *grand mal* and *petit mal* epilepsy which Jackson diagnosed as affections of the highest level. There is a spasm, not in a single part of the body, but of the whole, and consciousness is lost at the outset.

Pedagogical Application of the Level Theory. Pathological practice in the diseases of dissolution, or "devolution," of the nervous system now accepts the essential conception of the Jacksonian theory as a successful working hypothesis, recognizing, however, that it is a general scheme rather than a detailed plan of proven facts accurate in detail. Its applications have, however, never yet been made to psychology and pedagogy. Education deals with the normal evolution of the nervous system. It therefore in a sense takes a complementary view to that of nervous pathology. May it not be that the introduction of the Jacksonian view of the nervous system may prove as serviceable to education as a working hypothesis, as it has in pathology? In crude outline we must recognize in this hierarchal scheme of the nervous system, the analogy of its phylogenetic development. In the lower invertebrates, we find, not a centralized nervous system with a cerebral or even spinal central stations, but a loose system of local ganglia regulating, in more or less independent manner, special movements of the animal. In higher orders chain ganglia appear with a growing approach to centralization. In vertebrates we find the chain system transformed into the spinal system and within the cranium are ganglia of the special sense organs, developing in complexity and centralization as we go up the scale. Flechsig's highest association centers, presiding over higher reason, if we accept them, extend as a tapering tongue far down the mammalian scale. The human nervous system, therefore, from this view point is the jointed product of evolutionary increments. It sums all stages of its historic evolution. Within it are preserved the primitive forms of nervous control as well as the last products of evolution. The reflex level finds its analogy in the lowest forms of life; the cerebro-spinal system represents a later addition; the highest level is essentially a human accession. The progress of development upward through the levels is a progress from simplicity to complexity, from that which is oldest racially to that which is newest, from that which is fixed and unyielding to the environment, to that which is plastic and yielding to environmental changes. Is it possible that in mental and physical growth from the human infant to maturity we may trace, with practical suggestion and profit to education, the phylogenetic joints of his historic evolution?

From the order of development in maturity of the fibre bundles of the spinal cord and brain, it is conclusive that each bundle has its special period of immaturity, of plastic growth;

and finally fixed maturity when modification is difficult or impossible. This middle nascent period is the period for education. "We know," says Clouston, "that each center has its own nascent or growth period, which is sometimes very short, as it must be in the center in which movements of sucking are co-ordinated; and sometimes very long as in those in which we co-ordinate the movements of the hand, from its first feeble grasp up to its consummate achievements in making and shaping."

On the side of external movement we see corresponding phenomena in development. The cord reflexes appear and perfect themselves, largely in early infancy, it is true, but nevertheless they continue to develop until a comparatively late period. Certain reflex movements of the eye, opening or closing upon stimuli of light, moving upward and downward, one side to the other, are mature in the early hours of life; but the capability of a specific object in the field of vision to control and direct these movements, is not manifest generally for several weeks, and an act of volitional control which we may regard as an interference of the highest center does not appear for several months. The infant can grasp with its fingers in the first hours of life, but it is several months before it uses the thumb in its grasping movement. Many of the most delicate movements, accomplished by nicest adjustments of the highest centers, do not appear until very late in childhood. On the other hand, many of the eye adjustments pass to the control of the higher centers, undoubtedly, in infancy. Therefore we must carefully avoid the notion of the maturity of all the nervous processes occurring at a specific time or period. We must on the contrary conceive the process as one occurring separately in many thousands of activities depending upon as many neural developments, each pursuing its progress from birth to senescence, reaching different levels of activity at different times and at different rates of progress. However, with the clear recognition of this principle, and the manifest incorrectness of the conception that would lead us to say in an absolute sense, that the reflex level, as a whole, matures at a certain period and then rests; that the cortical sense-centers, as a whole, next mature, and finally that the highest level matures; still facts may warrant us in concluding that certain general periods may be characterized by predominance of nascencies in a given level. Thus it certainly may be said that in infancy the nascencies of the lower level outnumber those of the middle and higher, that in childhood up to puberty the sense-center nascencies predominate, though lower level processes continue to appear and a fair number of highest level nascencies occur; and that finally in the adolescent period highest level growths predominate.

There are many facts which go to support this tripartite progress of nascencies, in a loose sense. Insanity, for example, is rare in children under fifteen years, and Mercier explains this fact on the ground that children under the pubertal age do not yet possess mature higher centers. Insanity under modern interpretation is an affection of the centers of the highest level. Disregarding senescence, it has been found that the greater number of insanities occur in the later ages of maturity,—in men from 40 to 60, and in women from 30 to 50. However, Mercier is only loosely correct in saying that insanity does not occur until after puberty, and the exception confirms the principle put forth that the highest center is slowly maturing in some fields of activity from infancy through childhood. It is not so frequent, probably because there are fewer parts matured, and perhaps these, since they are the earliest found, are the oldest phylogenetically, and hence more resistant than many later formations. According to Boutteville, the proportion of insane children to insane adults is as follows: From 5 to 9 years, 0.9 per cent.; 10 to 14, 3.5 per cent.; 15 to 19, 20 per cent. Winslow finds only eight children under ten years of age among 21,333 insane patients. But with the beginning of puberty there is developed a variety of psychic phenomena, which, while only temporary, are none the less to be classified as within the borderland of insanity,—irritability of temper (*i. e.*, lack of inhibitive control by the highest centers), morbid notions ranging into hallucinations, etc. Insanity in children when it occurs, according to Ireland, is generally an after-effect of certain diseases, tubercular meningitis and fevers which, we can readily understand, tear down the tissues of the highest centers. The gradations of epileptic diseases indicate a growth by periods. Epilepsy in all its forms, may perhaps be regarded as a disease of nervous instability. A development upward through the levels has been traced. Certain forms as the respiratory infantile convulsions and other attacks of the lowest level are most common in infancy; Jacksonian epilepsy of the middle levels predominates later in childhood; genuine epilepsy is most frequent later still. Still, all varieties do occur to some extent in the early period, illustrating the probable fact which has been pointed out that all systems commence to grow at an early period. Gowers has shown that out of 1,450 cases of various epilepsies 29 per cent. began in patients under ten years; 46 per cent. between ten and twenty years; 15.7 per cent. between 20 and 30; 6 per cent. between 30 and 40; and 2 per cent. to 1.5 per cent. after 40.

As a frank speculation, may we not ask whether it is not plausible, in a loose sense, that the period of predominating culmi-

nation and extreme nascency of the highest level, unfolds at a time beginning roughly with puberty and lasting throughout the earlier years of adolescence: whether the period of culminating nascency of the middle-level system does not begin about the second year of life and gradually mature throughout the early ages of childhood, reaching a period of ripened but slow growth in the three years just preceding puberty: whether the reflex system is not most active in earliest infancy, and as we see in the gradual maturity of reflexes reach its maturity about the second year?

In an unconscious but nevertheless clearly established way, these three periods have for practical purposes always been distinctly insisted upon by the popular mind. Infancy has been recognized as a period for learning to creep, to walk, to maintain the equilibrium and to use hand, arms, and legs in the countless movements that later become reflex. Childhood, by ancient and familiar dogma, is the period for training the sense-centers. No period, however, has been so clearly recognized as that of the nascency of the highest system in adolescence. It is a common statement that it is not till a child is thirteen or fourteen years of age, the pubertal period, that he is capable of rational thought and reason. The school has always insisted upon this, giving memory topics in the earlier years and reserving the rational study, requiring higher correlation for the later period. In all religions, civilized and savage, there are religious rites, perhaps dependent in origin on sexual changes, but, nevertheless, changes which are clearly conceived as psychic as well, recognizing that the child takes on at this time the adult's logical thought. The confirmation services in our established churches are evidences about us, and in evangelical churches there is a prejudice against accepting a religious judgment until after the child is thirteen or fourteen years. On the other hand, this is the period the child himself chooses to make them. Rousseau clearly expresses a wide-spread sentiment, when he asserts, that until twelve years the child should grow practically wild, and Aristotle in his ideal state would begin the first really psychic judgments, based on higher association, at fourteen.

May we indeed not go still further, and, upon a basis of ontogenetic and phylogenetic parallelism, speculatively raise the question whether or not these nascencies in the reflex, middle, and highest levels do not carry with them specific biological characteristics; whether it is not true that in infancy we do find evidences of the rudimentary instinct of spinal life in a biologic sense; whether in childhood, the instincts that have been most closely associated with middle-level activity in an evolutionary sense do not now predomi-

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nantly appear ; and finally whether we may not find in adolescence the appearance of certain higher atavistic associates of the highest level, more characteristic of man's higher and later development. At least in a crude general way is it not probable the methods of learning new things, of thinking and reaching conclusions in action and even in thought do not pass through these three stages of growth, so that tendencies, interests, and instincts developed by a lower system built by a subsequent growth of fibres from the highest system tend to be replaced by higher level forms in a natural way? It is more than a merely plausible hypothesis that if the structure governing a given nervous reaction in an activity is carried forward by evolution from a lower to a higher organism, the reaction itself of this transmitted structure must also tend to be reproduced, preserving amid accessory human types of reasoning the vestigial tendencies of earlier racial habits. And it is more than merely plausible, from all we now know of the structure and processes of the nervous system, that the accessory or highest human types of action and thought only reach this highest stage by passing through, in infancy and childhood, the lower level types of this process. We must not place emphasis upon the number of levels which the Jacksonian theory has employed, for that has been a rather arbitrary assumption. There may be many levels. The central conception is that the higher processes are formed by combination of elements and structures of a lower process already existing. Children frequently persist in following some strange, useless or even savage interests quite foreign to our civilization. Upon this doctrine of development by levels, these strange and useless experiences nevertheless may be essential as a platform, out of which a higher co-ordination, useful for modern life, may be reached. The intermediate stage or level may be useless or even inimical to our civilization, but yet as a link in evolution, be none the less essential.

A system of education following the order of developing nascencies in the parts of the brain would, in all probability, find itself in opposition to many of the methods of the present curriculum of the primary school. At least the present practical pedagogy is based largely upon the logical cleavage of the subject studied, and has given little or no attention to the order of development by nascency. If the abstract reasoning is largely a process of association of centers of the highest level, and if, as facts seem to point, the highest level does not reach its stage of predominating nascency until the adolescent period, then the so-called reasoning process, as it appears in adult life and in childhood, cannot reasonably be presumed to be identical in essential character. The reasoning of the adult

must involve a large area of centers, and a more intricate concatenation. Yet school practice, relying partly upon notions of metaphysical rationalism and folk-thought has naively assumed that the process by which children and adults reach conclusions are identical.

FROM FUNDAMENTAL TO ACCESSORY IN MOVEMENT.

Muscular movement is the complement of nervous activity. If there has been an evolution from fundamental to accessory forms of structure in the nervous system we must expect to find a similar evolution in the character of movements. Facts answer fully these requirements of theory. The movements which are regulated predominantly by the accessory structures of the nervous system show certain characteristics distinctly differing from those regulated by the fundamental parts of the nervous system. An illustration of accessory movements in the sense of those which are not possessed by animals lower than man is offered by the complex capabilities of the human hand. To bring out the characteristics of the accessory hand movements as distinguished from the fundamental movements, we may compare them either with fundamental movements of the human body, *e. g.*, the trunk movements, and with fore-limb movements of lower animals. The first comparison has been carefully made by Dr. Mercier, though with no attention to evolutionary significance, in his distinction between "central" and "peripheral" movements. By central movements he means those made by the trunk and more central portions of the body[1], and by "peripheral" he means the movements made by the hand, articulatory muscles, etc. But the terms in the comparison chosen, practically coincide with "fundamental" and "accessory" respectively, since the trunk movements are those which man has in common with lower animals and a large class of hand movements have been added in human experience, though another class are clearly fundamental. Dr. Mercier points out in the first place (1) that the trunk movements are few and resemble one another in kind, while the peripheral movements are countless in variety and number. The movements of the trunk are limited chiefly to leanings, some slight ability to rotate, and to the respiratory function. "With each step that we take towards the periphery, the number of movements that can be executed and the amount of difference between these movements increases, until at length when the periphery is reached, the number and variety of movements becomes enormous. The area over which the hand can be moved is almost as large as that of a sphere whose radius is the length of the arm, and the hand can reach three-fourths of the points between the shoul-

[1] The Nervous System and Mind.

der and the area thus marked out." In order to realize the innumerable positions members of the extreme periphery may take, we have but to note a pianist's hands and fingers in movement. (2) The most significant distinction to which Dr. Mercier draws attention is that in the association of two or more movements, the distinctive tendency of central muscles is to make them simultaneous or alternating, while the accessory muscles are distinctively capable of long and complex sequences. The legs in walking alternate and there is even bilateral tendency in using the whole area for the other arm to move simultaneously. Compare with these the power of the hand in writing, or the articulatory muscles in speech to maintain long series of movements in accurate sequence. The first term of the series being stimulated the other terms follow in an accurate order and nicety which is marvellous when we attempt to analyze them. Consider for example the habit of sequence which is developed in the fingers of the pianist. (3) The central movements are crude in any work requiring precision and delicate co-ordination. The central movements enter as associates into these co-ordinations by providing steadiness, but the finer movements are performed by the periphery. (4) The peripheral movements bear to the central the relation of the special to the general. We cannot use our fingers in writing till by the central movements the arm is brought into position and held steadily. We cannot speak without the general movements of breathing which force the air through the larynx. The peripheral movements, aided by their power of acting successively and with greater complexity, perform special feats.

It would be a faulty explanation of these striking differences in the characteristics of central and of peripheral movements to assert that the differences are due a larger number of muscles in the hand[1]. The number of muscles in the entire arm exceed those of the trunk very slightly. The marvellous adaptability of the hand can only be explained on the ground that the higher levels of the nervous system combine the lower level movements into the countless new complexes and introduce the features of sequence, precision, etc., which for the fundamental levels are practically impossible.

Many movements of the hand are of course fundamental, and the theory of superposition in the governing nervous structure is prettily shown by the phenomena of certain nervous diseases. General paralysis that begins in the highest

[1] Quain's Anatomy, p. 186, gives the number of muscles in the body as follows: Head and neck, 75; vertebral column, 51; upper limb, 58; lower limb, 54.

centers is accompanied in slighter attacks with almost imperceptible interference with precision; the patient is not able to execute the finer delicate movements. As the disease spreads downward, these more general, more complex, more precise movements are lost layer by layer as it were, from accessory to fundamental, from peripheral to central, from highest to lowest level, from the products of latest evolution to those of the older. Such devolution may be illustrated in the early loss of writing without appreciable loss of fundamental movements of the hand; by the early loss of speech without loss of eating or swallowing movements of the throat, nor any paralysis of the tongue and lips. In downward progress of disease—in devolution so to speak,—the loss of higher level centers results in loss of peripheral or accessory movements, frequently leaving the fundamental movements quite unimpaired.

It remains briefly to compare the movements of the human hand with the movements of the fore limbs of lower animals for the purpose of noting that these characteristic differences between higher accessory human movements and those of animals are the same that exist between the accessory (peripheral) and fundamental (central) movements in the human body; and secondly, to offer further evidence that the explanation of these differences parallels the differences between the accessory and fundamental levels of the nervous system.

However different the movements of the fore limb of man and brutes, however varied the degree of complexity and the diversity of purpose for which these movements are employed, nevertheless the fundamental structure in all is singularly similar.[1] Place drawings of the skeletons of the human hand and of the fin of a whale side by side and ordinary observers will require the printed names underneath to distinguish them. The muscular framework offers greater differences it is true, but the difference in the arrangement of muscles between a monkey hand and a human hand offers scarcely any proportionate hint of the real differences in their capabilities of movement. There is always a cluster of bones forming an ankle or wrist, and proceeding peripherally from it a series of bones, actual or rudimentary, forming what may be called rays. All originate from the primary purpose of locomotion. M. Bernard suggests the crocodile as a living example of this primary type, by whom the fore as well as the hind limbs are used solely for locomotion, though if we choose to go further

[1] For an excellent comparison see M. Bernard, Pop. Sci. Mo., Feb., 1898.

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back we find the fin of the fish similarly used. Now, in most of these early types, the movements are very few and simple, practically limited to movement forward and backward in a single plane ; there is practically no rotatory movement either in the shoulder or other joints, and the digital extremities are not used for grasping except in a very rudimentary way. As we go up the scale of evolutionary differentiation we find new movements and a few new anatomical modifications, but the former are in far larger proportion. Bears develop claws, and with them a clutching movement for climbing trees or holding prey ; ungulates, for rapidity of flight ; carnivora, for rapidity and strength in pursuit, endurance and holding or tearing prey. But in all these modifications the number of different movements is extremely few ; they are without complexity, dominated by the character of simultaneity, making slight use of the principle of succession ; they are without relation, and are all executed nearly in the same plane. In the movements of clutching, tearing, etc., there is no independent movement of the digits, but these are merely transformed into a sort of claw, and the real work is done by the more central muscles which draw this hook in one plane, thus useful in tearing, pulling, digging, etc. Moreover, in all animals below the primates, with few exceptions such as birds, rodents, etc., the movements which are not those of locomotion are merely incidental and reach no important degree of complexity. The toes in the great mass of common carnivora and ungulates are used for walking ; the joints stiffen and, as in the case of the horse, some atrophy and practically disappear. With the arboreal life of the Simian species, a new environment has worked wonders with the limbs. In life among the branches of trees and the necessity for dexterous and agile movements of the limbs, the monkey family seem, compared with the lower animals, to have made a progress that amounts seemingly to a difference in kind. In point of form of hand and arm movements, though not in perfection, complexity, and in ability to execute series of successive movements, the apes probably are nearer akin to man than to the lower animals.[1] Apes have to some extent the power of bringing the thumb into opposition,[2] but the ape grasp, as some one has said, is adapted for seizing a cylinder, while man's grasp is adapted for seizing a sphere as well. Compared with man,

[1] Broca, Revue d'Anthropologie, 1872, p. 26, concludes that anthropomorphous apes approach more nearly the bipedal than the quadrupedal type.

[2] See Turner. Pres. Address before anthropological section of the Brit. Ass'n for Advancement of Science. Nature, Sept. 2, 1897. Dr. Hepbren, Jour. Anat. and Phys., XXVI.

Broca[1] found that the arc of rotation of the forearm of certain monkeys is not more than 90 degrees, while, according to the same investigator, it reaches 140 in the chimpanzee and 180 degrees in man.

It is unnecessary to multiply examples. It is evident from this brief survey that progress in evolution of hand movements in the biologic scale has been from extreme fewness in number to infinite variety, from simplicity to complexity, from clumsy inaccuracy to precision, from simultaneous associations to those which constitute long series in sequence, from the general to the specialized. Secondly, it is evident that the slight differences in bony or muscular structure are far inadequate to explain these enormous differences between accessory and fundamental. The jaws, teeth, tongue and palate of lower vertebrates are not so radically distinguishable from those of men to account for the rapidity, complexity, marvellous precision, accurate co-ordination and successiveness involved in human speech. Yet a civilized man uses a score of thousand words or more, each requiring a special and appropriate set of movements, different from all others; and moreover he throws these together in sentences requiring successive co-ordinations of long sequences with marvellous precision and rapidity. When we attempt to measure the gap between man and the lower animals in terms of power of movement, the wonder is no less great than when we use terms of mentality. We are forced back again for an explanation of this marvellous complexity of adjustment to the nervous system, and to conclude that the difference in associational capability between the accessory and fundamental levels must indeed be significant. A chapter essential for the completeness in the educational application of the principle which has been thus treated, would attempt to show at this point that the individual from infancy to maturity passes through stages of movement from those which possess the fundamental characteristics to those which are accessory. This discussion, however, must be reserved for a subsequent place.

Relation of Accessory Hand Movements to Human Intelligence. In previous sections the evolution of the nervous system and the evolution of movement have been traced separately. The present section will deal with data suggestive of the intimate correlation, in the progressive evolutionary stages of the nervous centers employed in psychical activity and of those concerned in muscular movement. The data in the evolution of the human hand will chiefly be used as the material for illustration.

The intimate relationships existing between higher intelligence and the more highly developed accessory motility of the

[1] Bull: Soc. Anthrop., 1869, p. 301.

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human hand has been so striking that it has been noted even so far back as Anaxagoras. The extreme theory has been put forth by many modern writers that human intelligence, as such, has arisen in direct consequence of man's assuming the upright position. The fore limbs, thus relieved of the duties of locomotion which in lower animals is more or less their exclusive function, have found vent for their energy in manifold new employments, and thus introduced the human race to varied world of richer experiences. Intelligence has been the product.

Trace the evolution of the higher human intelligence as we will,—from toolmaking and tool-using to modern invention, from manual signmaking to speech, from hut building to architecture, from picture-writing to painting, from bizarre fashioning of fetiches to sculpture, from rude drumming to higher instrumental music—the development of hand and mentality have ever been in the closest intimacy of association. Under the simple psychological law that processes occurring simultaneously tend to fuse, we have reason to expect, in advance of evidence, that the accessory hand movements and accessory mental powers of man should be singularly related.

There is much in psychology that supports the general theory. Dr. Stricker in his *Bewegungsvorstellungen* contends that in every mental act of the imagination there is a tendency to muscular movement which in many persons rises above the threshold of consciousness. In his own case, when he imagines a man walking he feels simultaneously a tendency in his thigh to move his own leg. When he succeeds in suppressing these muscular tendencies he finds himself unable to imagine. This phenomenon is in accord with modern psychological views. In order to raise the arm, for example, the motor mechanism is set off by the sensory centers which hold in memory the impressions that were received from the joints, muscles, etc., when on previous occasions the arm was lifted; these sensory impulses arising from the movement of some portion of the body have been termed "kinæsthetic" sensations. Consequently when Dr. Stricker imagines a man walking, these kinæsthetic memories are reawakened, and, perhaps, form essential elements in the imagination of the general act of walking as performed by another person.

Darwin, Duchenne, Pidirit and Mantegazza have studied the significance of the expressive movements, especially of the face and hands, and in general conclude that these are weakened forms of movements that were once directed to some practical end; that is, the kinaesthetic sensations that once set off a purposive action, now reappear by force of association with specific traces of their former subjective states in weakened

form,[1] and set the movements *partially* in action; hence the clenching of hands in anger, the contraction in fear, etc. In other words, the physiological states which are paralleled by their concomitant mental states are made up of partial re-excitations of ancestral movements.[1] Theodate Smith[2] conducted a series of experiments on muscular memory in the laboratory and found that the kinaesthetic sensatious of speech movements are essential to memory of words; that the memory of visual forms is greatly assisted by associating with the forms to be remembered certain hand movements and as her experiments show, memory thus prepared is from 10 to 22 per cent. freer from error than memory based upon visual observation alone. In this line of speculation, we find ourselves in the end not far from the conviction that the movements of the hand, by racial predisposition and individual education, have some singular connections with the highest level activities of ideation; that thus, in plausible probability, the nervous reaction associated with certain hand movements in lower levels has become represented, "re-represented" and "re-represented" in successive levels, till quite divorced from its previous associate in muscular action, it becomes the nervous structure used exclusively in ideation.

To be explicit, let us trace speculatively by way of illustration the evolution of the nerve processes concerned in a state of moral courage. Our brute-man ancestors did not think courage—they acted it. The kinaesthetic memories of previous similar acts flowed directly into the motor channels of muscular reaction without the complex association of the higher levels. Since consciousness is a concomitant only of sensory processes and not of motor discharges, according to the psychological view now generally accepted, consciousness was of brief duration because the discharge was immediate. Later, however, a portion of the kinaesthetic energy, instead of being wholly discharged into motor channels to excite muscular movement, forced itself upward into higher levels and gradually formed long circuits of sensory irradiation among the structures which are the concomitants of higher ideation. By this irradiation, consciousness was prolonged and the energy given to muscular action lessened. The individual deliberated longer and acted less. The kinaesthetic impulses that discharged into the motor channels of our ancestors, creating in them deeds of physical courage, discharge, in the more complex nervous system of their civilized posterity, into the higher levels and excite this moral courage of thought, let us

[1] Compare Lindley, *Am. Jour. Psy.*, Vol. VII, p. 506.
[2] *Am. Jour. Psy.*, Vol. VII, pp. 453-490.

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hope. Hamlet failed to act—he philosophized. The human race in its evolution, has been playing the role of the Dane over and over again. The moody Hamlet stands meditating in the focus of civilized consciousness while the old tendencies to action in the lower levels, lurk in the emotional twilight of the margin, tingling our nerves and exciting us with the feelings of our ancestry. Such is the prevalent theory summed up in the phrase, "thought is repressed action."

For suppport of this standpoint, theory would require that distinctly lower grades of intelligence should be accompanied by deficiency in manual motility. The lower primates and the human idiot offer fair tests of this requirement. The ape shows rudimentary degrees of human intelligence, just as he also manifests rudimentary human hand movements. The ape arm is capable of rotation at the shoulder and partially capable of extensions, supination and pronation from the elbow joint, but these powers find only their final perfection in man; some species are able to rotate the forearm almost to the human extent; in common with man many species are able to bring the thumb in opposition to the fingers but compared with that of man the movement is very imperfect. They have nearly all the structural movements of flexion, extension of fingers and even some slight lateral movements.

The feeble minded show marked deficiencies in power of movement and, in general, are wanting in just those movements which specially distinguish the human species from lower animals.

"In the will movements," says Johnson,[1] "the difference between the control of the fundamental and accessory muscles was much more marked in the feeble-minded than in normal children. This was more noticeable, the greater the degree of idiocy. Some who could execute gross movements with regularity and control were wholly deficient in the execution of finer movements." Even those who walked strongly were utterly devoid of grace of movement which is the product of finer control by the higher levels of the nervous system. Mr. Johnson gives a number of tests and observations and concludes: "The foregoing observations and tests are corroborative of Mr. Hancock's conclusion (from normal children) that the fundamental precedes the accessory in development of motor ability. It is important to note that all the spontaneous movements were fundamental. Hardly a single one of them could be considered accessory. They were the swaying of the trunk, the movement of the jaw, swinging of the arm,

[1] *Ped. Sem.*, Vol. III, p. 281.

reeling of the head, and the simplest finger movements." Says Dr. Ireland:[1] "The best and earliest sign of idiocy is the deficiency of the grasp. The hand is flapped or vibrated about instead of being employed to seize or obtain an object. Imbeciles are clumsy in the use of the hands *and it is difficult to teach them any exercise of handicraft requiring method and dexterity*. Even imbeciles are generally very inexpert at such exercises as catching a ball or aiming at anything and *it is difficult to teach them greater dexterity*."

Dr. Seguin thus describes a typical idiotic hand: "The hand of R. is small, the nails short and brittle, fingers as if unfinished, no power, no skill, only automatic movements mainly from the wrist. He could not put his fingers in any given attitude. He could not rotate on command that wrist so nimble when striking or vibrating automatically. He could obey the movements of elevation and abduction, but not always, nor with anything like precision."

Féré has gathered the data not only of structural defects of the idiotic hand but he also goes so far as to insist that degrees of intelligence among normal individuals show traces of a direct relation to their hand motility. He finds that the arm of normal individuals admits of elbow rotation inwardly, 15° to 25°, and outwardly 200° to 225°. In idiots, this power of rotation is comparatively very limited. Goutton has pointed out that in many idiots and cretins the power is entirely absent. It will be remembered in this connection that in monkeys this ability to rotate the forearm outwardly is 140° at maximum. In the matter of ability readily to bring the ball of the thumb and fingers into opposition a large percentage of the feeble-minded are able merely to bring the finger points together in the pincer form of the monkey tribe. Sometimes there is inability to bring the thumb in opposition to the little finger. This failure in many cases is to be accounted for by the weakness of the thumb—a characteristic Simian weakness. The last joint of the fingers and thumb in monkeys and idiots alike, is frequently abnormally short. Féré[2] compares the length of this joint (the last phalange, or phalangette) of imbeciles with that of normal persons engaged in occupations requiring manual dexterity and finds a range of length expressed in percentage of the length of the whole hand as follows: thumb, 13 to 20 per cent.; index, 10 to 15½ per cent.; middle, 10 to 16 per cent.; ring, 9½ to 16 per cent.; little, 8 to 13 per cent. He concludes: "The subjects in whom one finds the phalangette more developed are in general

[1] Blot on the Brain, p. 257.
[2] Rev. Phil., Vol. XLI, p. 622.

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those who have given proof not only of manual dexterity of movement but also of mental development above the average, while the individuals who are singular for the shortness of the phalangette are *without exception* imbeciles." The phalangette of the thumb is largely controlled in its most delicate manipulations of precise movements by the long flexor muscle, which is absent, according to Gratiolet, in anthropoid apes. It is in the movements controlled by this muscle, according to Féré, that imbeciles show a conspicuous weakness. He remarks that he has observed that persons employed in mental work maintain without exercise, nevertheless, a high motility of the thumb muscles. The arrest of development of the ring and little fingers is common among degenerates making many movements impossible; the fingers are short or lack the power of independent flexion or to put themselves in the same plane with the others. The flexion of fingers is always more forcible than extension, and in degenerates this difference is as a rule greatly augmented.

Another series of hand defects of significance is that of the lateral movement of the fingers. This power is partially regulated by the depth of the space between the fingers, a greater depth allowing greater freedom of lateral movements. In the gorilla, for example, the interdigital membrane is large and reaches far up between the fingers, binding their action. Hartman[1] has found this same feature noticeable in many of the lower human races, notably negro. In some species of monkeys the fingers are united. Imbeciles frequently show what seems an atavistic tendency in this direction; in persons of normal intelligence, says Féré, the thumb for example, can be brought to make an angle of 120° to 130° with the index, but in degenerates it is frequently not more than 45°; the same ratio holds with the other finger angles. Johnson[2] found by examination a very general difficulty among feeble-minded children to open and close the fingers laterally; some could open the hand between the index and middle finger but not between others. Some who could open fingers laterally could not open the first finger alone. In attempting these movements false movements were often made; for instance, swinging of wrist, partly closing hand, or shaking whole forearm. These latter substitutions illustrate the weakness of the control of the higher over the lower centers.

Féré concludes regarding the power of independent finger movements as follows:[3] "The disassociated movements of the

[1] Les Singes Anthropoids, Bibl. Sci. Internal, p. 80.
[2] *Ped. Sem.*, Vol. III, p. 28.
[3] Rev. Phil., Vol. XLI, p. 624.

fingers present considerable variation. With individuals of higher intellectual endowment they are more developed and are accomplished with less energy and greater rapidity. In the degree that one descends in degenerescence, these movements are less numerous, less rapid and less precise; while with individuals of greater intelligence, the amount of work of the fingers acting successively is greater than the work of the fingers acting conjointly." In another work[1] Féré shows that ability to move fingers separately, or to move one hand without the other, is small among the imbecile class. The normal individual is better able to direct effort and to concentrate energy into specific members acting independently. This tendency of the imbecile class to simultaneous movements suggests atavism since simultaneity is the dominating law of the fundamental movements and succession is the human characteristic of accessory movements. Simultaneous movements of the hand suggests reversion to the conditions when the hand was a fore limb.

As a rule, in school children, those of quick movement of muscles are considered brighter, mentally, than those of slower movement. Of course this condition may represent a variety of causes, but this fact is very readily apparent on the whole. In a study which was made to trace the rate of school progress of some two hundred children, it was found that 52 per cent. of the most rapid pupils possessed strikingly quick control of the movements while only 8 per cent. of this class were slow of movement; on the other hand among the pupils of slow progress 40 per cent. were strikingly halting in their movements, and only 25 per cent. possessed a ready control. Also, in the matter of precision 54 per cent. of the rapid pupils possessed accuracy of writing movements against 11 per cent. who were not; while among the mentally slowest, 59 per cent. lacked accuracy of movement and 22 per cent. of them were not precise.[1]

The facts which have been reviewed bring out clearly the close, and seemingly organic, relationship existing between these nervous structures controlling the movements which constitute man's superiority over lower animals, and those nervous structures which function human mentality. The mentally defective are commonly deficient in the ability to control these accessory movements and show many similarities to Simian traits of structure and movement. Such facts necessarily push us toward the conclusion that defects of mentality, as in power

[1] Epilepsies et Epileptiques.
[2] Burk: Individual Pupils vs. Graded System, Northwest. Monthly, March, 1898.

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of movement, are commonly due to the failure of higher levels of the nervous system to become functional — levels which are essential both to a higher class of movements and a higher stage of mentality. It is an interesting corroboration of this view that in the other class of highly specialized accessory movements, speech, idiots show a very common deficiency. Dr. Down from an examination of 200 idiots, 7 to 36 years of age, found 33 mute, 16 semi-mute, 83 with indistinctness, 4 stammering, and 62 with fair speech. It is manifestly incorrect to treat idiots as a single class having a common cause of defect. It is with the congenital class that this inquiry is specially concerned, for under this classification fall those unfortunates that date their defect, in the words of Dr. Down, "from earlier uterine life and in many cases to the germ or sperm cell."[1] The studies upon the finer cortical structures in the brains of congenital idiots, which already have been briefly reviewed in the first pages of this article, show striking deficiencies in number of cells, development of the cells in size and in the association fibres connecting them with other cells. The lower centers in the cord, medulla and pons are much more frequently normal. Kaes, who perhaps has made the most fruitful investigation thus far, voices a growing conclusion that both deficiencies in finer structure and the frequent grosser abnormalities find a common origin in an early embryonic period where an arrest of development has occurred, which has thrown the organism off the track leading to complete human development as it were; thus derailed, the nervous system tends to develop, in some features, toward lower racial forms, dependent upon the period at which the arrest occurred and the structures affected. In this line of speculation, Dr. Down some years ago contributed a classification of congenital idiots according to ethnic types — Negroids, Malays, Indians, Mongols. He asserts that more than 10 per cent. of the congenital feeble-minded children are typical Mongols. "They present characteristics so marked that when members of this type are placed in proximity it is difficult to believe that they are brothers or sisters. In fact their resemblance is infinitely greater than to members of their own family."

The simple educational and psychological significance of the facts of this chapter is that the individual, from conception to senescence, follows the order of development of the race, and that any serious mishaps upon the way causes an arrest of development of his nervous system at some partial level. But the facts, except in these extreme cases of arrest, are far from fatalistic in their inferences. Even among the idiot class, the results of

[1] Wood's Monographs, Vol. X, p. 320.

education upon the principle of developing the more fundamental in order to develop the accessory, have approached the marvellous. Those two classics on the subject by Dr. Seguin, "The Idiotic Hand"[1] and "The Idiotic Eye,"[2] illuminate the principle by practical results that are of the most significant value to general education; truly does the editor of *Archives of Medicine* say in announcing Dr. Seguin's death that "the great physio-psychological conception (illustrated practically by Dr. Seguin) must in time — perhaps a long time — attract the attention of teachers in kindergarten schools and colleges." Dr. Seguin began the education of the idiot by training of the hand movements, and of these he selected for the first lessons those which were most fundamental — grasping, supporting, letting go, throwing, catching and leading up gradually by some admirable teaching tact to the accessory, and correlation of eye and hand in natural exercises that called forth the pupil's interest. Strangely, after two years education on this plan, the general mentality of the boy whom he describes had also improved to a degree that was marvellous even to teachers. The stimulation of the evolutionary levels, in their natural order, through the hand training had strengthened them also for discharge of mental functions.

Evolution of Hand Movements in the Development of the Normal Child.

The topic of the present chapter is a difficult one. We meet a baffling complexity and seeming disorder, upon any logical basis, from the moment of birth. Some of the movements of new-born infants are extremely simple, and a large number seem to be built up by co-ordination of these simple movements. But on the other hand there are strewn throughout infancy and early childhood a number of singular movements, which, at their first appearances are highly complex; they are excited by special stimuli; many of them by irregular modification become adapted to ends for which evidently they were not originally employed. If infants first learned to make all the simple reflexes, and this step performed, then proceeded to combine these elements into new unities, and so on, we would have a logical order to retrace. But there are few evidences either in infancy or in later childhood of such steps from the logically simple to the complex. Preyer has shown that in the case of the eyes, each eye tends to a certain extent to be a law unto itself, that the two do not move in perfect co-ordinated unison until several months have passed; yet the same principle will not apply to the movements of the two arms. This

[1] Archives of Medicine. [2] *Ibid.*

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pair of bilateral members tend to move simultaneously, when an adult would use one of them independently.[1] Mrs. Moore's child was eight months before it ever used the two hands simultaneously for different purposes. Such conflicts are inexplicable upon any basis of uniform principle. The evolution theory, however, of course steps forward to explain this anomaly on the ground that in animal ancestry the eyes moved independently of each other, while the arms or the fore limbs, on the contrary, moved by bilateral impulses. The facts of observation make the matter even more complex, for we find in very early infancy many co-ordinated movements of the eye, *under certain conditions*[2] and independent arm movements *under certain conditions*. It may be these can be explained on the biological grounds that certain co-ordinated movements of eyes and independent movements of arms are older or more firmly established than others of the same classes respectively.

Ready-made Complexes. We may begin by illustration of some of these singular complex co-ordinations which Minerva-like appear full-fledged at birth. A striking example of this class is offered by Dr. Robinson[3] in experiments upon the ability of new-born infants to hold themselves suspended by grasping a finger or a bar. If we accept the current theory that the immediate ancestry of man lived in trees as many species of monkeys now do, this movement, though highly complex, involving the combination and co-ordination of several muscles of the arm, wrist, and fingers, is, in an evolutionary sense, fundamental. Dr. Robinson has kept records of experiments upon sixty infants, carried out within an hour after birth in the case of at least one-half of them. The infant subject was allowed to grasp a horizontal bar, or a finger, and left suspended in this way, sustaining its own weight. He says that in every case, with only two exceptions, the child was able to hold on "for at least 10 seconds: in 12 cases with infants under one hour old half a minute passed before the grasp relaxed, and in three or four nearly a minute. When about four days old I found the strength had increased, and that nearly all when tried at this age could sustain their weight for half a minute. At about a fortnight or three weeks after birth, the faculty appeared to have attained its maximum, for several at this period succeeded in hanging for over a minute and one-half, two for just two minutes, and one infant of three weeks of age for two minutes and thirty-five seconds."

[1] Mrs. W. S. Hall: First 500 days of Child's Life, Child Study Monthly, Dec., 1896.

[2] Mrs. K. C. Moore: Mental Development of a Child, Psy. Rev. Monograph Supp., No. 3.

[3] Darwinism in Nursery, Nineteenth Century, Nov., 1891.

Dr. Robinson remarks that the feat is one which would tax the powers of an adult. Wallace has recorded a similar condition of the infant monkey's grasp; one which had seemed secured a hold upon his beard clung so tightly that Wallace was not able, without help, to free himself. In similar vein Dr. Mumford[1] has made an interesting speculation showing the analogy of certain very early movements of the infant to the paddling movements of water animals. He thinks them survival movements of aquatic life. These movements he points out disappear early in the first year, or are modified to form elements of more complex movements higher in the evolutionary scale. The feat of hanging from a stick or finger by the hands, logically would imply the prior development of the arm, shoulder, wrist and finger movements. But such are not the facts. The child grasps a stick and hangs suspended by his arms, long before he is able to pick up any object, or put his two hands together or lift hand to mouth. Logically, the grasp of the whole hand would follow the grasp by the parts, but observation shows us that a certain kind of complex grasp is one of the earliest movements, developed long before some of the very simplest finger movements. Any logical explanation fails at this point. Evolutionary explanation is plausible, for so far as the positive evidence of observation goes the more fundamental and older racial movements appear before the newer and less fundamental, regardless of the order of complexity, except in so far as the accessory as a rule tends to be more complex than the fundamental.

If the human adult or child, beyond the age of infancy, grasps some object, as a saucer or a cup, so large that he cannot put the fingers around it, the arm will be extended toward the object, thumb uppermost, the palm facing upward. The thumb plays the chief role; the last joint hooks over the rim and presses firmly downward, while the fingers underneath press in an opposite direction. This is not the Simian method. The Simian thumb is not strong nor motile enough for one reason, and in the second place it is not its habitual form of grasp. The thumb in the monkey is comparatively of little use, and, as already stated, some species are lacking in the muscle of its chief control. The fingers are used chiefly as a single hook, and in the most arboreal species[1] the fingers have grown together to form a grasping hook. With them, the hand in grasping is used in just the reverse form. The fingers are uppermost, thumb underneath, the palm downward, and the grasp is accomplished by the fingers pressing downwards

[1] Survival Movements of Human Infancy, Brain, No. 79, 1897.
[1] Buckman: Babies and Monkeys, Nineteenth Century, Nov., 1894.

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against the palm. Infants follow the method of monkeys, not of man. Give a baby a saucer, or better a glass of water, and note that the rim is seized by the hand with the palm downward, instead of upward as in the case of an older person, while the thumb plays the role of a useless fifth wheel to a wagon.

By what process is the transition to the adult form of grasp accomplished? Undoubtedly imitation is the final directing cause, but there is a functional difficulty in the retarded development of the infant's thumb. He is born with a monkey thumb and must first obtain a human thumb and be able to use it in perfect opposition. Preyer, Mumford and Mrs. Winfred S. Hall have given detailed descriptions of the development of the thumb. For the first two or three months of life the thumb is really a nuisance to the child and is continually in the way. Generally it is curled inside of the grasp. In the case of Mrs. Hall's child it was not till the 11th week that the thumb was brought outside the hand when the latter was clenched.

On the fifth day, Axel Preyer clasped with his fingers his father's finger and it was not until the 12th week that there was certain evidence that the thumb was reflexly brought into use, and even in the 32d week, the movement was not entirely perfect. Mrs. Moore's child was first observed to use the thumb in opposition during 12th week, but she records that it was not till the end of the first year that this method had become established. In the case of Dr. Mumford's child in the 12th week, the diary records: "Does not use his thumb properly for grasping; when he tries to bring the bottle toward him he tucks the thumb out of the way. For the past fortnight he has begun to grasp with his fingers." In the 16th week there is this record: "Has been using his thumb more and more and now never shuts it inside but always outside." In the 28th week, the last record given, we learn that "Grasping movements are much more perfect but still he does not pick up things between the tip of the thumb and finger. Occasionally he grasps a thing between the last joint of the thumb and finger." Mumford concludes that it is often six months before the development of thumb make the elaborate movements of the human grasp possible. While the thumb of the hand is thus gradually gaining in motility and strength *in a human direction*, the great toe is losing motility and strength, *also in a human direction*. Robinson[1] attests from a number of experiments upon new born infants of an English workhouse, that young infants curl their toes over anything grasp-

[1] British Med. Jour., Dec. 5, 1891.

able. When either the palm of the hand or the sole of the foot is touched, the reflex grasp of the fingers or toes is occasioned. Buckman observes that a baby can move any of its toes independently and can move them one from another so as to make a V between any of them. Preyer records that on the seventh day, his child grasped a thin pencil by his toes exactly as by the hand.[1] As the child grows older this power is lost. It is a movement which in the development of humanity has been lost. Mumford records that in the 28th week the toes of his child had lost almost completely the tendency to grasp.

Several other hand movements could be more or less definitely traced, commencing in the infant with complex reflexes, inexplicable as yet upon any theory except that of evolutionary origin, and developing into human forms by modifications and additions that show no trace of logical arrangement. Among these to which reference might be given are the change from rhythmical sluggish movements of the fingers (which Mumford considers a survival from aquatic habits) to human quickness; development from the hooked form and use of the fingers,[2] to independent movement of finger; the habit of using the index to poke about in investigating crannies or new objects;[3] the method of grasping a ball, etc. These constitute but one class of elements with which the child commences his career. They are not simple in the sense of logic for they are not complexes made up by co-ordination of several simple movements previously possessed; the infants who hang suspended by the grasp do not usually grasp objects which merely touch their fingers; the grasping reflex is only set off by touch in the palm of the hand.[4]

Nor do all these complex but original co-ordinations appear immediately at birth. They are scattered along through infancy and childhood suggestively corresponding to the development by distinct parts observed in the growth of the nervous system. The teasing and bullying instincts of children offer suggestive illustration. Among the commonest movements in these activities may be observed;[5] pursuing, throwing missiles, striking, throwing down, holding down, dancing about conquered victim, laughing, clapping hands, pulling hair, pulling ears, etc. Children's natural games are largely made up of mild forms of these elements, the more malevolent tendencies having been elided. Whence came these movements which children acquire without effort and which they execute

[1] Senses and Will, p. 245.
[2] Buckman: *Ibid.*
[3] Mumford: *Ibid.*
[4] Mrs. Moore, S. and W. 243.
[5] Burk: *Pedagogical Seminary*, April, 1897.

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with such natural grace and precision. They have no utilitarian bearing upon the duties of civilized life. A plausible hypothesis classes them with the grasping reflexes of newborn infants—habits common to the race in its primitive conditions and carried forward in the structure of the lower levels of the nervous system.

These complex movements are ultimate units; they do not conform to the purposes of civilized human conduct and are not explicable nor reducible by any process of logical explanation. Corresponding to them are psychic states of equal complexity which find no explanation in the civilized child's present environment. There is a principle well known in physiology and embryology, that a structure or a movement—useful for a certain purpose in a certain stage of the biological scale, loses this purpose in a higher stage and through modification becomes used for some entirely different purpose. This is what Wundt terms heterogony of purpose. Thus as we have seen the fingers have been used for locomotion, then for seizing, grasping, and finally, in man, their ancient purpose is wholly lost, and an entirely new series of uses has taken its place, though the bony structure has not materially changed. Now what are the applications of this view to many of these strange complexes that appear in early childhood, even to include such seemingly evil forms as those which appear in cruelty, bullying and teasing? May it not be, indeed, that they constitute a level in the evolutionary hierarchy, and though in themselves useless, are nevertheless an essential platform from which the co-ordinations of a higher and useful level are formed? It is plausible that the child needs to live to some extent the life of his ancestors in order actually to develop in his own nervous system the kinæsthetic sensations which by the process of higher evolution may serve as the basis for higher forms of activity in the highest levels? It becomes indeed a question of extreme nicety to determine just the exact moment when sufficient actual experience has fully established the racial tendency and the time for inhibition and radiation of the force into higher cerebral associations should follow. Danger of arrest of development at the lower stage is as important as that the fundamental impressions should not be made. Such a view gives these curious phenomena a natural place in child life, and emphasizes the probability that children's plays and games, as mild vaccination forms, serve as mediations between brutal ancestral tendencies in the nervous system, and the higher levels employed in altruistic modern life, between savage racial action and civilized ideation.

Co-ordination of Simple Movements. One who watches a young infant will notice a number of jerky movements contin-

ually occurring in practically all the muscles of the body. Some are merely slight twitchings of fingers and small muscles, and they range in scope to those of flinging hand, forearm, or whole arm about vigorously; the legs are moved in the same way. In the same class we must place the play of features, turnings of the eye and various other awkward movements. In some of these movements Mumford finds a rhythm which he thus describes. "Slow rhythmical movements of flexion and extension of the fingers occur, which instead of possessing the quick-incisive character of voluntary movements partake of the sluggish rhythm so familiar to the visitors to the tanks of an aquarium. They often occur in a series of three at a time during a quarter of a minute; then follows a pause during which there is apparently an accumulation of energy in the nerve cells. Then another series of spontaneous discharges takes place, to be in turn followed by another pause." Preyer has described the whole class of these movements as "impulsive" and labors to show that they are "spontaneous" impulses from the nervous system, occurring without external stimulus but exclusively by organic or nutritive processes. This clear-cut division which excludes all external stimulus probably is to be seriously questioned, but this is immaterial for the present. Notwithstanding the evident fact that these movements possess strength and energy,[1] the new born infant is unable to direct his hand or arm movements. He cannot for some days or even weeks bring his hand to his month. Accidentally, in these movements, the hand frequently is thrown to the mouth and the infant sucks his finger; he is unable to remove the thumb from his mouth and must wait till some adult or lucky accident of movement removes it for him. Without purpose and without manifest external stimulus, the elbow, wrist, and finger joints are continually being flexed. Even months before birth these purposeless movements had commenced. What is the significance? As Flechsig has shown, in earliest infancy, practically the whole cerebral cortex is scarcely connected by mature fibres with the centers of action in the spinal cord, medulla and pons. It is not till well into the first month that these earliest connections are made on the sensory side, and the motor connections by which activity is cerebrally directed donot appear until after the sensory has developed. The child is several months old before all portions of the sensory bundles of fibres which pass from the cord to the cortex show maturity in every part.

These movements are most common in the earliest weeks of infancy, and tend gradually to disappear. The fact that the

[1] The strength, under specific stimuli, is demonstrated by the grasp and the power of bodily suspension.

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connections of the lower centers with the cortex are not made till late, leaves us to conclude that these early movements are the products of spinal activity, uncontrolled as yet by the higher levels. They are lowest level movements in their simplicity, unmodified by the inhibitions of later human experience which lie undeveloped in the higher strata of the nervous system. They must represent the movements which are racially the oldest entering as elements into human activity. If lower animal movements do appear in human activity, it is in this period we most safely can look for them in their most undifferentiated form. Later in infancy the first connections with the cortex are established. Then sensory fibres go upward, and later motor fibres go downward from these middle centers, to inhibit and control the lower movements in certain particulars. Associations of cell with cell, center with center, develop to modify and make more precise or offer greater alterations in these modifications. Later, a still higher system of control is superposed upon this. From this point of view, the purposeless movements of infants are more intelligible. They are movements without higher inhibition, movements as yet without halter or rein. The objective evidence bears out this supposition. Gradually, this flopping of arm, rhythmic flexions, and extensions, and nervous twitchings tend to disappear. Just in proportion to the capability of an infant to execute voluntary movements of a given limb or organ, these vagrant movements disappear. The two opposed processes are gradual, and Warner[1] records that at three years microkinesis, as he terms it, is still present. It is questionable that these movements ever do completely disappear, as experiments upon the ataxiagraph show. In form, these purposeless movements may be, as Mumford and others claim, survival movements of past ancestry. As such they are useless and senseless, and if this were their only significance they well might be destroyed. Nevertheless they unquestionably have a far more significant place. Children without them are idiots.[2] The modern will theory certainly gives them a functional place. Before a movement can become voluntary, certain sensations of the muscles, skin, joints, etc., occasioned by this movement, must be recorded in memory. These sensations, in form of memory deposit, become the stimuli by which voluntary action is directed and controlled. By these memory traces, just the exact amount of force, the direction, and the method of precision is measured out, when a given movement comes to be voluntarily employed. Sully gives an apt description of this

[1] Mental Science, April, 1889, p. 36.
[2] Tuke's Dictionary of Psychological Medicine, p. 469.

process in an infant eleven weeks old.[1] "Among the objects that attracted him was his mamma's dress, which had a dark ground with small white flower pattern. His hand accidentally came in contact with one of the folds of her dress lying over the breast. In a dozen times or more he repeated the movement of stretching out his hand, clutching the fold and giving it a good pull. A hasty reasoner might easily suppose that the child had now learned to reach out to an object when only seen. But the sequel showed this was not the case. Four weeks later, the diary observes, the child as yet made no attempt to grasp an object offered to him. The clutching was thus a blind movement. Yet it was doubtless a step in the process of learning to grasp." A simple explanation would be that the kinæsthetic impulses consequent from the first accidental reaching and clutching served as stimuli by which the action was repeated, and so on till fatigue set in.

In the light of this consideration, the importance of these rhythmic movements, be they survivals of aquatic and arboreal life or not, is manifest. If through any disorder, the lower levels are unable to produce them and the infant lies quiet and motionless, these sensations, necessary for willed action, never occur, the physical concomitants of mentality are never stored, and the infant lives to become an idiot. These movements, the flotsam and the jetsam of spinal activity uncontrolled as yet by higher centers, are the ultimate units. If we admit that they are survival movements we have here an illustration of a widespread physiological principle, that new uses are grafted upon old structures.

The modifications of the ultimates, whether complex or comparatively simple, with which the infant begins life, proceeds in several directions: (1) the breaking up of old bilateral and simultaneous tendencies, characteristic of central movements; (2) the growth of independent movements of smaller parts that previously only moved in conjunction with larger wholes; (3) the co-ordination of various series to form long and complex sequences as we finally find them illustrated by writing, sewing, piano-playing, etc.; (4) the development of precision and accuracy; and finally (5) the response of different movements to a great variety of different stimuli. These modifications perhaps represent the chief accessory lines of development that distinguish human movements as such. Any attempt to give a concrete review of these movements would of course require a volume. Merely a few typical illustrations will be made. Under head of bilateral tendencies which give way to independent movements, Mrs. Hall[1] reports that during the first

[1] Studies of Childhood, p. 413. [1] *Ibid.*

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few months the right hand was always carried to the mouth with the simultaneous movement of the left hand. "Even when putting the thumb to his mouth he used the left hand in this way, and finally held the left hand under the right hand while sucking the right thumb. If the left hand was confined so that he could not use it in this way, it was noticeably harder for him to put the right hand to his mouth, while it always annoyed him, causing him to cry." We must be careful not to confuse the age of a movement with the age of a child. I think it is probably true that any new hand movement attempted at any age tends to be bilaterally simultaneous. For example, children of any age, in learning to play the piano are able only after considerable practice, to make movements independently with each hand. Few adults, without practice, will be able to move the left hand in a circle to the left while the right is making a similar circle to the right. Hancock experimented upon 142 children asking them to pat the top of the head with one hand while they made a circular motion about the breast with the other. Forty-five failed entirely, while the others were more or less successful after a time. Bilateral movement is older than independent movement of the hands; the former doubtless is the order of the lower levels; it is overcome by control from the higher accessory centers.

The formation of a successive series from parts previously existing may be illustrated by the following type described by Mrs. Hall. The age of the child was 13 months. "After watching two children play ball he was allowed to join the game. The ball was rolled to him, he picked it up, then leaning far forward placed it upon the floor, but could not push it away. His hand was repeatedly given an impulse which sent the ball forward but even then he could not roll it alone. The ball was thrown to him and he tried to return it, but after raising his arm and reaching the hand forward he could not propel the ball. Again he was assisted in making the requisite motion and when the ball left his hand he screamed with delight. After playing fifteen or twenty minutes, he raised the arm as if to throw the ball, then opened his hand and let it drop out but was unable to give it the forward impulse. The game was played daily and each time at the beginning of the play he experienced the old difficulty; but each day he succeeded after fewer trials than were necessary on the previous occasion, and finally learned to throw the ball in an awkward way. By the 58th week he had become able to throw it in the general direction of his effort, and by the 60th week to throw it with ease and with considerable accuracy."

In this description the difficulties of nervous co-ordination are clearly outlined. The child had already mastered all the

movements taken separately, but while these nerve centers could act separately, their co-ordination, not only in a general order of discharge, but in order of delicate nicety of time, was impossible. The forearm must be extended at just the exact moment and the ball released at another precise moment. When we consider the infinite complexity of the whole process our wonder is that it is so quickly acquired. The suggestion leads to the query whether or not movements of similar complexity, but entirely new in racial experience, are learned as readily in later life. I hardly believe they are. Throwing is almost an exclusively human movement though some monkeys have been known to possess it. In strictly human experience, however, it is old and firmly established. May it not be possible that the explanation for the comparative ease with which the child learns this movement be accounted for on the theory that in learning he is retracing paths in his nervous system, more or less distinctly established by ancestral experience? An adult required to perform a movement of similar complexity but entirely new in human experience would not learn as readily and rapidly as the child of thirteen months. Some such supposition is necessary to account for such facts of which this illustration is but a type.

A more complex type of co-ordination, though it represents a much earlier period of life, is illustrated by the following comical instance.[1] "In the 17th week the breast was shown to him while he still held his thumb in his mouth, and then for the first time he seemed to realize that the two were separate and he must release the thumb before obtaining the breast. Up to this time the thumb had been removed for him, but on this occasion no assistance was given him until he himself had made an effort and had failed. He looked at the breast, then worked at the thumb, then cried, but could not take it from his mouth. He was therefore assisted and given the breast. Each time he nursed he was required to make the effort to remove the thumb, and was afterwards given such help as was necessary. Late the next day, after a long trial and some crying, he succeeded in his efforts, whereupon he made a little sound of satisfaction and seized the breast. Six days later he was able to remove the thumb at will and with ease." Leaving out the writer's interpolaton of mental motives, which, perhaps, are not essential, we might, perhaps, express the physical conditions something as follows: In the form of accident, so to speak, the nervous apparatus is matured sufficiently to place the hand to the mouth and also to remove it; further, there is established already a co-ordination between

[1] Mrs. Hall: *Ibid.*

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the centers of smell or of sight, so that when stimulated suitably, they excite the movements necessary to take the breast; but the presence of the ungovernable thumb prevents. We clearly have here the separate parts of a somewhat complex co-ordination, but co-ordination is wanting. We know certainly that at this age, four months, some paths to and from the central convolutions of the cortex are matured, especially on the sensory side. Of all sensations that would first develop, on account of their early use, we must conclude that those concerned directly and indirectly with sucking would be conveyed there. Of all kinaesthetic sensations of arm and hand movements which also would be likely to be the earliest to develop in the middle cortical level, those of movement of the hand to and from the mouth would be first, for these are the earliest acquired movements. For six days this hand is specifically trained in removing itself, in close association with sensation from olfactory, visual and hunger centers that are clamorously importuning that something be done, and that something be done quickly. An accident in the path of predisposition solves the difficulty for the first time. Each repetition of it makes the transit easier. The co-ordination is established and it is established in just the same way that racial infancy has established it. Gradually higher centers are developed receiving impulses from the lower, co-ordinating them anew and discharging inhibitive motor impulses, substituting or adding other movements. These, at a still later period, are made the basis for a similar superposition. The earliest progress of a child in movements is in the realm of what is racially fixed and determined. Only with the maturing of the highest centers, factors of extreme plasticity, choice, freedom from racial predisposition are introduced.

This brings us to a point of view of the highest pedagogical significance, to wit, that in the development of co-ordination from lowest to highest, the power of evolutionary habit decreases, and the possibility for special modification increases; that there is a progress in teachableness, or at least the term, education, must be taken in two different senses. In the lower strata of development, where the steps have been worn by racial experience, education that is most serviceable will be that which takes its cue from the racial stimuli and concerns itself with leading co-ordination to take these fixed steps as truly as possible. But later, as the higher strata are reached, when the movement emerges from this deep worn gorge that ancestry has trodden and comes to the point where racial paths are divergent and indistinct, the definition of education changes. Education has now a wider sweep of vision, and instead of following paths, may sight distant goals and lead

more directly to it. In a different terminology we might call this early education which is restricted to aiding the child to follow in the steps of his ancestors "fundamental," and that which finds its place later, that which comes in when racial paths grow shallow and divergent, and originality more possible, we might call "accessory" education. Taking wider range in this thought, we may consider the child as the sum of his movements. We must remember, nevertheless, the principle of development by parts, by which some parts reach maturity at later periods than others so that we can never say, in an exact sense, that the child is now in the "fundamental" period of education and then in the "accessory." But in a crude, inexact way, it is certainly true that more lines of accessory education are possible in adolescence than in childhood, more in childhood than in infancy. Using the word "teachable" in the accessory sense, we may say that the child is far more teachable than the infant. Dr. Harris has said that education must be governed chiefly by the needs of objective environment. This assertion is too universal. It is education defined only in the accessory sense. A teacher with only this view plays the part of the bull in a china shop in dealing with those mechanisms of fundamental education which would require us merely to follow racial traces.

There is a familiar dispute in pedagogy whether or not the child should be always allowed to follow his inclinations. One party maintains the extreme position that we should follow blindly the child's interest. Another party stands aghast at the proposal. From this present standpoint taken must we not first discover whether a specific tendency in question is "fundamental" or "accessory?" If deeply fundamental, we must follow nature. If the tendency is one in its accessory period of development, we may perhaps allow objective factors largely to determine.

The child traverses before he is six or seven years old, not only the long deep worn road of racial ancestry, reaching back perhaps as far as arboreal or even aquatic life, but I think we may say, he takes a few paces in certain few co-ordinations that are his own, blazes a few trees and leaves his mark. As we shall later see, by six years of age, he shows evidences in many lines of being far upon the highway of distinctively human capabilities of movement. His fingers and hand that once tended to act only upon the lower simultaneous principle, now can move in fair degree by the principles of independence, and of succession. In the delicate steadiness of central movements and the complex co-ordinations requiring delicate peripheral movements, he has probably acquired half of the ability he ever will acquire. His nervous system has made a prodigous

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growth—far outstripping any other system. The co-ordinations which have made this possible are the products of this growth.

Development of Hand Movements During School Ages.

The present chapter will undertake to review briefly the few studies which have been made upon children of school ages by psycho-physical methods, to determine the rapidity, accuracy, strength and maturity, and fluctuating periods in the development of hand movements. The data, incidentally, however, is suggestive for many other pedagogical problems.

Rapidity of Movement. Dr. W. L. Bryan,[1] in Worcester, and Dr. Gilbert at Yale[2] and Iowa,[3] have experimented upon the degree of rapidity with which children of different ages were able to tap an electric key which automatically recorded results. Dr. Bryan thus tested four sets of arm muscles—shoulder, elbow, wrist and metacarpo-phalangeal finger-joints. In order to secure the free separation of these sets of muscles, the arm of the subject was clamped by means of certain devices to allow movement only of the specific set of muscles. The test in all cases was the greatest possible number of taps the subject could execute in five seconds.[4] The number of children (public schools of Worcester) used in the results here referred to is 729. They ranged in age from 5 to 16 years.

The following tables for boys and girls give the arithmetical mean of the tests (right arm) of all boys, and of all girls of a given age.

Table A.—*Boys.*

Age	5	6	7	8	9	10	11	12	13	14	15	16
No.	14	26	35	33	43	37	36	33	34	41	32	26
Finger	19.6	19.5	21.0	23.1	24.4	55.2	27.0	29.3	28.7	31.5	31.6	33.9
Wrist	20.1	23.0	23.7	26.3	27.8	28.5	30.3	31.6	32.3	33.0	34.2	35.9
Elbow	22.7	23.5	24.2	26.1	28.2	28.1	29.3	29.9	31.0	32.7	31.5	32.7
Shoulder	18.4	19.8	20.5	22.3	24.1	22.6	24.1	25.0	25.5	27.2	26.3	28.7

Girls.

Age	6	7	8	9	10	11	12	13	14	15	16
No.	28	32	33	43	37	36	33	34	41	32	26
Finger	19.8	20.7	22.2	24.0	25.8	27.1	28.2	30.3	29.5	29.1	31.3
Wrist	21.6	23.1	24.3	25.5	28.5	30.4	31.6	33.2	30.3	30.9	33.3
Elbow	22.7	23.2	24.4	25.4	27.5	28.6	29.4	30.5	28.8	29.3	30.1
Shoulder	19.9	20.2	21.9	22.7	22.6	24.9	25.7	27.5	26.6	26.0	27.9

[1] Development of Voluntary Motor Ability, *Am. Jour. Psy.*, Nov. 1892.

[2] Studies from Yale Psy. Lab., Vol. I.

[3] Univ. of Iowa Studies in Psy., Vol. I.

[4] The mechanism and conditions are so complex in detail that the reader must be referred to the original article for them.

Dr. Gilbert has made two studies upon rapidity of tapping, one upon New Haven children and one upon Iowa children. In his tests the elbow was held free from the table and the arm was in no way clamped. The subject tapped with the finger but the movement must be interpreted largely as that of a wrist movement. The number of children was approximately 50 for each sex and each age, from 6 to 17 years of age. The number of taps in five seconds for both sexes is shown by the following table:

TABLE B.

Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19
New Haven Boys	21.0	22.8	24.9	25.8	27.7	29.7	30.3	29.8	31.2	31.3	33.0	35.0		
Iowa Boys	22.1	23.3	25.8	27.1	28.3	28.1	30.1	31.1	32.4	34.0	34.0	34.4	36.0	36.7
New Haven Girls	19.7	21.2	23.9	25.0	26.9	27.8	29.6	28.1	28.0	29.8	31.8	31.5		
Iowa Girls	22.3	24.2	26.0	26.7	26.2	28.0	29.3	29.5	29.4	31.3	32.2	33.8	34.3	35.3

Without holding Drs. Bryan and Gilbert responsible for the form of all conclusions, we may draw from their studies the following inferences:

I. The rapidity of motor ability of the hand and arm, as indicated by tapping, increases, on the whole, with age and does not reach maturity until the adolescent period.

The results of both Dr. Bryan's and Dr. Gilbert's studies agree in demonstrating this fact conclusively. The rate, though subject to several fluctuations, very significantly increases from six years through the pubescent period. The immaturity of this movement at the age of entering school is shown by the following table of percentages, assuming the rate of tapping at 16 years as 100 per cent.

TABLE C.

	Per cent. of 16-yr. ability possessed at 6 years of age.		Per cent. of 16-yr. ability acquired between 6 and 16 years.	
	Boys.	Girls.	Boys.	Girls.
(Bryan.)				
Finger	57	63	43	37
Wrist	64	65	36	35
Elbow	72	75	28	25
Shoulder	69	71	31	29
(Gilbert.				
Hand (N. H.)	64	62	36	38
Hand (Iowa)	65	69	35	31

None of Dr. Bryan's tests are directly comparable with Dr. Gilbert's, since the subjects in latter held the arm entirely free,

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and their movement, therefore, is probably a combination of all four of the movements studied by Dr. Bryan.

This fact of the comparative immaturity of children's motor ability excites the pedagogical inquiry whether or not in the existing school requirements, stick laying, needle work, pencil work, etc., of the kindergarten (children under 6 years), and in the writing and drawing of primary children there is intelligent realization that the child's ability, so far as rapidity of movement is a symbol of maturity, is only 60 to 70 per cent. of what it is at 16 years.

II. Girls mature earlier than boys in rapidity of hand and arm movements. This is manifest by a glance at the tables. As shown in Table C, the girls in all but one test (New Haven) have, at 6 years, reached a larger percentage of their 16-year ability than the boys. At 13 years girls have reached practical maturity, and the rate in some of the tests actually decreases after that age. Bryan's girls at 13 years have acquired 97 per cent in the finger test, 99 per cent. in the wrist test, 101 per cent. in the elbow test, and 98.2 per cent. in the shoulder test. In general, therefore, we may say, girls reach practical maturity in rapidity of arm and hand movements at 13 years, while boys increase very materially their ability after 15 years of age.

III. The rate of improvement in rapidity is not regular from year to year, but proceeds by very marked fluctuations, or rhythmical vibrations. Sometimes the rate is very rapid, and again slow, even in some years showing a decrease from the rate of the previous year. Both Bryan's and Gilbert's tables agree in showing four periods of acceleration and four periods of retardation in rate between the years 6 and 17, though there is slight divergence for specific years. The years of highest rate for boys are as follows:

Worcester,	8th and 9th,	11th,	14th,	16th.
New Haven,	8th,	10th and 11th,	14th,	16th.
Iowa,	8th,	12th,	14th and 15th,	18th.

The years of lowest rate are as follows:

Worcester,	10th,	13th,	15th.
New Haven,	9th,	13th,	15th.
Iowa,	11th,	13th,	16th.

Rapidity of movements of hand and arm, in tapping, tends to be greatest when the rate of growth in height and weight is least, and *vice versa*.

This relationship is shown by comparison of the annual rate of growth in height, weight, as given by Dr. Gilbert, and, in the case of Worcester children, by measurements and weighings taken by Dr. G. M. West. In making the conclusion we need not necessarily presume upon any organic relation

between rapidity and the growth rate, but it is probable that the processes of rapid anabolism in the addition of new tissues, at least interferes with the dexterity of movement. In Bryan's data the 10th and 15th years, which are the lowest in tapping ability, are the highest in growth rate. In the New Haven study the years of retarded tapping ability are the 9th, 13th 15th and 17th; while the years of accelerated growth rate are the 9th, 11th, 13th and 15th.

V. The more central (fundamental) movements tend to mature earlier than the less central (less fundamental) movements.

Dr. Bryan's tests, which deal with the movements of shoulder, and elbow, wrist and finger, separately, offer evidence upon this point, though perhaps strictly speaking, no one of these movements, except that of the finger, can be considered exclusively accessory or fundamental. In table D this relative immaturity of the finger movement is clearly shown. At 6 years, the finger has acquired, in both girls and boys, a distinctly smaller percentage of its ability at 16 years of age, than any of the others, and the wrist movement is less developed than elbow and shoulder. It has been shown that growth in power proceeds by rhythms and it becomes interesting to know in quantitative form the relative amounts of development that are added within each of these rhythms of advancing age. Table D is constructed with a view of showing this. Each retardation with its succeeding acceleration is considered a period; there are thus in the case of boys four periods: 6 to 9, 9 to 12, 12 to 14, 14 to 16; in the case of girls three periods: 6 to 10, 10 to 13, 13 to 16. The tapping ability at 16 years is taken as 100 per cent., and the figures in the columns indicate the percentage of this 16-year ability added in each of these respective rhythms:

TABLE D.

Boys' Right Arm.

Age	Up to 6 years.	6–9	9–12	12–14	14–16	Total at 16.
Finger . . .	58	14	14	7	7	100
Wrist	64	13	11	4	8	100
Elbow . . .	72	14	5	9	0	100
Shoulder . .	69	15	7	4	5	100

Girls' Right Arm.

Age	Up to 6 years.	6–10	10–13	13–16	Total at 16.	
Finger . . .	63	20	14	3	100	
Wrist	65	21	14	0	100	
Elbow . . .	75	15	10	0	100	
Shoulder . .	71	10	18	1	100	

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These tables show: (1) that in both boys and girls alike, the elbow and shoulder movements have reached a larger per cent. of their mature power than the finger and wrist movements; of the two classes the finger is doubtless more of an accessory movement and of later evolutionary development; (2) that the finger movement acquires a large per cent. of its ability after nine or ten years of age— 28 % in the boys and 17.5 % in the girls. Dr. Bryan, by a different series of calculations, reaches the same conclusions and says: "These results show that the shoulder grows most slowly and the elbow slightly faster, the wrist and finger very much more rapidly." A table stating the number of taps, the elbow, wrist and finger exceeds that of the shoulder, at each age, shows that while this surplus in the case of the elbow is only slight throughout the period from 6 to 16; in the case of the wrist, this surplus doubles and increases from six to sixteen fold. The wrist and finger do not gain materially upon the shoulder until the 11th year and then the finger rates, relatively, spring forward at a greatly accelerated rate. The explanation suggests itself that the shoulder as a central movement has passed the period of extreme nascency very early, the elbow follows, the wrist makes its gains still later and the period of nascency for the finger is certainly not till after 10 years of age and probably does not reach its real culmination in power until sixteen years. Such nascencies have important significance in the management of manual school work.

Development of Strength. Peron early in this century showed by experiments with the dynamometer that Malays and the natives of New Holland are distinctly inferior, in strength of the hand and arm, to French marines. That the civilized races are distinctly superior in hand and arm strength to the lower races of man has many times since been confirmed by Manouvrier[1] and others. M. Féré goes further and contends that among individuals of the same race, the more intelligent have the greater strength of hand. He says[2] that the same dynamometer test, taken upon individuals belonging to different classes of society, have shown that the pressure produced by the effort of flexing the fingers is less with workmen whose profession is exclusively manual than with those whose work requires less muscular force, but whose intelligence comes more into play; and further, that the muscular power is still greater with those of the liberal profession of the same age. The close intimacy of mentality and hand force is demonstrated by M. Féré's well known

[1] Rev. Philos., 1884, Vol. I, p. 645.
[2] Rev. Philos., Vol. XLI, p. 623.

dynamometric experiments[1] showing that the power is very significantly affected by emotional and intellectual states. A subject whose dynamometric force is normally 50-55, shows a decrease to 45 when affected by a disagreeable odor, while an agreeable one causes an increase to 65. In another subject the odor of musk raises the force from a normal 23 to 46. Music and colors produce similar varying effects and various intellectual states show no less pronounced influences. Féré formulates the law from his dynamometric tests that the energy of momentary effort is in proportion to the habitual intellectual functions.

The few statistical studies which have been attempted upon the development of strength during the growing years of childhood and adolescence have been made by Dr. Porter upon St. Louis children,[2] Dr. Gilbert upon Iowa[3] children, and Mr. Roberts in England.[4] The following table gives the absolute annual increments of strength obtained by subtracting the test of one year from that of the next. Dr. Porter's test was made by means of the dynamometer, an instrument which registered mainly the hand-grip power, which, as we have seen, involves one of the most fundamental movements appearing in the first hours of life. Dr. Gilbert's wrist lift involves the hand and fingers, but the principal strain is upon the wrist. The arm

TABLE E.

AGE.	PORTER. Hand-squeeze. Annual increase in kg.		GILBERT. Wrist-lift. Annual increase in kg.		ROBERTS. Arm-lift. Annual increase in lbs.		GILBERT. Arm-lift. Annual increase in kg.	
	B.	G.	B.	G.	B	G.	B.	G.
6½ to 7½ . .	1.6	1.4	1.7	1.0			8.4	6.8
7½ " 8½ . .	1.7	1.6	0.8	1.0			9.5	4.1
8½ " 9½ . .	2.0	1.1	1.1	0.0		1.0	7.2	6.5
9½ " 10½ . .	1.5	1.2	1.7	1.5		0.1	9.6	−1.3
10½ " 11½ . .	1.5	1.4	0.5	0.5		2.3	9.5	7.7
11½ " 12½ . .	2.3	1.7	1.7	0.1	1.0	1.2	7.7	6.3
12½ " 13½ . .	2.4	2.7	1.0	1.9	5.7	3.5	8.6	11.3
13½ " 14½ . .	3.2	1.9	1.1	0.6	2.8	3.2	12.8	6.4
14½ " 15½ . .	4.4	2.0	4.6	1.2	6.0	4.1	23.0	5.4
15½ " 16½ . .	4.4	1.8	3.3	.6	9.6	2.2	8.3	−3.2
16½ " 17½ . .		0.1	3.3	.4	6.4	2.1	20.0	2.8
17½ " 18½ . .			0.0	1.2	2.2	5.0	13.6	1.4
18½ " 19½ . .			1.7	0.0	1.5	1.9	0.0	3.8

[1] Sensation et Mouvement.

[2] Growth of St. Louis Children, Trans. Acad. Sch., St. Louis, March, 1893.

[3] *Ibid.*

[4] Report of Parliamentary Commission on Secondary Education, Vol. V, p. 363.

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lifts of Roberts and Dr. Gilbert test fingers, wrist, elbow, and shoulder. They are therefore not safely comparable one with the other. I have arranged them, however, in parallel columns to show whatever parallelism there may be in additions of strength taken in a general sense.

It is clear from this table that strength varies from year to year in rhythms as we have observed in all other tests. The chief accelerations begin in boys from 13 to 14, and continue probably almost until 18 years. In girls the period of acceleration begins a year or so earlier, and, as a rule, begins to decline from 15 to 16; there seems to be a new acceleration after 18 years. From 6 to 10 or 11 years occur periods of gradual increase with very marked fluctuations. In order to determine the relative proportions of increase that occur in different periods I have calculated the following tables. The strength at 16 years has been taken as a base or 100 per cent. By subtraction the other columns are obtained.

TABLE F.

	Per cent. of 16-yr. strength acquired by 6 yrs.	Per cent of 16-yr. strength acquired by 11 yrs.	Per cent of 16-yr. strength acquired between 6 and 11 yrs.	Per cent of 16-yr. strength acquired between 11 and 16 yrs.
Boys.				
Squeeze (Porter)	20	46	27	54
Wrist (Gilbert)	21	46	26	54
Arm (Gilbert)	24	64	22	44
Arm (Roberts)				36
Girls.				
Squeeze (Porter)	23	54	31	46
Wrist (Gilbert)	32	65	32	36
Arm (Gilbert)	32	67	23	45

From these calculations it would appear that in the case of boys only about a fifth of their 16-year-old strength is acquired before 6 years, a quarter from 6 to 11, and over one-half from 11 to 16, during the pubertal changes; in the case of the test upon the whole arm maturity is somewhat in advance. In the case of girls a greater share is acquired before 6 years, their strength acquirement is more rapid than with boys from 6 to 11 years, although the largest increment is added also during the pubertal flux.

These tests shed little light upon the question of the order of fundamental and accessory, since each of the tests largely involves fundamental movements exclusively. But in so far as the lift of the entire arm may perhaps be more exclusively fundamental than the combined movements of the wrist and hand alone, we see from the table that the arm movement seem to mature earlier than the wrist and hand.

Mr. L. W. Kline, in a statistical study of truant children,[1] finds that these children are significantly less developed, physically, on the average, than children of the public schools. He has kindly given me the data of dynamometer tests which he made, but did not use in his publication. These tests were made upon boys from 9 to 14, inclusive, in the Massachusetts truant schools. He also made identical tests upon a number of children attending the public schools of Worcester. While the number of children tested is not as large as desirable, nevertheless, a distinct cleavage is shown between the two classes, and goes to support the other evidences which indicate that hand strength, as well as motility, is in direct relation with the degree of mental development, or what is probably the same thing, strength depends to some extent upon the nerve centres of the higher levels. The following table compares the strengths of the truants and normal children:

TABLE G.

	TRUANTS.		NORMAL.	
Age.	No.	Mean Strength.	No.	Mean Strength.
9	19	23	69	26
10	20	25	83	30
11	30	30	102	38
12	31	36	121	40
13	47	40	102	46
14	23	51	90	53

Dr. Gilbert, in Iowa, segregated the "bright," "average" and "slow" children, according to their teacher's judgment. While in some tests, *e. g.*, rapidity of tapping, there was shown a distinct line of cleavage in favor of the bright children, yet in the tests of wrist and arm lift no cleavage is shown. Unfortunately, however, Dr. Gilbert combined the figures for both boys and girls in this comparison.

There is a fact of probable significance that the rate of increase in strength is high throughout the pubertal period, especially during the year in which the pubertal sexual changes chiefly occur, 14 to 15 in girls, and probably 15 to 16 in boys. In other tests there is generally a retardation during this particular period, the chief acceleration in height and weight occur before and after. The peculiarity is of significance in connection with a theory that has many supporters, that the seminal fluid has a direct effect upon strength. The relation is one which has been recognized from the time of the Greeks, who practically observed it in the training of their sol-

[1] *Pedagogical Seminary*, Jan., 1898.

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diers and athletes. Bierent[1] has developed this law, and the facts these tables express are in agreement with his conclusions.

The literature of strength — increases after seventeen years, with which we shall not deal — is very voluminous. The investigations which have been made indicate conclusively that growth in this direction is by no means at maturity at the age mentioned. The English Anthropometric Committee concludes that the increase is rapid, and then more slowly until 30 years, after which it tends to decline with an increasing rate.[2] He finds a parallelism between the increases of weight and strength.

Precision of Hand Movements. Superficial investigation shows that the nervous mechanism involved in the attempts to be precise with the finger, require first an adjustment of a larger area of muscular and nervous tissues than those of any other movement of the body probably. Precision in drawing a fine line accurately, for example, requires steadiness not only of the finger movement itself, but of the hand, the whole arm, and even of the body. If we observe a child learning to write we find that he holds his breath, and in many cases his legs will be found bracing his body in intense strain. The central muscles of the arm and trunk are called into activity to give support of steadiness as a necessary condition for the fine adjustment to follow.[3] We may, therefore, perhaps consider precision as involving two processes: (1) that of steadiness of the central organization as a platform upon which rests (2) the finer nervous adjustments of the most complex nervous elements.

1. *Central Steadiness.* This phase of the problem has been subjected to investigation by Hancock[4] in the effort of children to stand still. The subject was asked to stand with feet close together and hands at side, to keep his attention on a distant object, and to try to remain still for a minute. By means of the ataxiagraph attached to a cap worn on the head the bodily swayings of the subject are automatically registered upon smoked paper.[5] The test was made upon 168 boys and girls of Worcester, 5 to 7 years of age. His tests show that during these two years the girls gained in steadiness 32 or 33 per cent.

[1] La Puberté.

[2] Report of Anthropometric Committee, p. 37.

[3] Compare Mercier: Nervous System and Mind, pp. 94-97. Also Férè, Rev. Philos., Dec., 1897.

[4] Preliminary Study of Motor Ability, *Ped. Sem.*, Oct., 1894.

[5] The swaying in adults has been similarly tested by Bullard and Brackett, Boston Medical and Surgical Journal, Vol. I, p. 136, and Vol. II, p. 136; also Huisdale, Am. Medical Journal, Vol. XCIII, pp. 478-485

of the power of control at five years; and the boys gained about 15 or 16 per cent. We may say, therefore, as the indication of Professor Hancock's study, that power of central control increases with age (very rapidly at the ages 5 to 7), and more rapidly in girls than in boys.

Mr. H. S. Curtis in a study of inhibition tested the ability of children of various ages in their ability to sit absolutely still. He concludes: "The ordinary child cannot sit still voluntarily. Children under five years do not on the average sit still more than 30 seconds and children from 5 to 10 years not more than one minute and one-half. Mr. Curtis explains this condition on practically the same ground offered in the paper, viz., that the higher centers of voluntary control are not developed in any degree of maturity until a late period of child life. He finds that mental occupation materially assists in the control of muscular restlessness and that these higher centers of brain action are not developed until a comparatively late period.

Johnson experimented upon feeble-minded children,[1] 7 boys and 5 girls, averaging 13 years, by the same method that Hancock used. He found the average swaying slightly greater at this age than Hancock found among the normal children of five years. The former were of a high grade intelligence for their class.

(2) *Peripheral Unsteadiness.* Corresponding to these larger swayings of the central movements, there are numerous small vibrations in the peripheral muscles involved in the adjustment for fine movements. Though these movements are imperceptible to ordinary observation, they are always experimentally demonstrable. In early infancy these movements are more noticeable in the form of apparently nervous twitchings that constantly occur in nearly every muscle of the body, even during sleep. As has been stated, these are perfectly normal and are signs of health; they tend to disappear in conditions of lowered nutrition, and in idiot infants they are very much fewer or wholly absent.[2] As the infant grows older, they gradually grow fewer and less noticeable. The fact that they gradually tend to disappear may be explained on the ground that as the nervous and muscular mechanism is perfected, the lower mechanisms pass under control of higher brain levels.

Dr. E. H. Lindley[3] has made a study of the automatisms of early childhood and he shows the persistence of many of these earlier simpler forms into childhood and even into adolescence. Though in later childhood many of these simpler

[1] *Ped. Sem.*, Vol. III, p. 282.
[2] Hack Tuke's Dictionary of Psychological Medicine, p. 569.
[3] *Am. Jour. of Psychology*, July, 1896.

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movements are combined to form rather complex automatisms, as Dr. Lindley illustrates, nevertheless a large number remain below the threshold of ordinary observation, indicating a more or less incomplete co-ordination of motor discharge or storing of sensory impulses. Such co-ordinations clearly must interfere, as they are greater or less, with perfection of precision in fine finger movements requiring absolute steadiness. Dr. Lindley found that automatisms increase very perceptibly with fatigue, that they are most frequent in accessory muscles and, in general, decrease with age.

Professor Hancock[1] made an experimental test to determine quantitatively the unsteadiness of the shoulder, arm and hand, by means of the tremograph. He tested by this means 25 adult men, 62 boys and 34 girls from 5 to 7 years. The ability of the boys of 5 years was from one-tenth to one-fifth of that of the adults, and the ability of control improved about 50 per cent. from 5 to 7 years in the case of the boys and less for the girls. The girls possessed a much more mature control than boys of the same age.

(3) *Sensory Factors in Precision.* What has been said of these swaying tendencies of central and peripheral movements offers us evidence of the interfering factors which enter the problem of precision. A second series of conditioning factors in obtaining precision, lies in the sensory development. A movement is determined, the modern view of voluntary movement holds, by the sensory kinæsthetic impressions which are stored up in memory. A movement is made, at first accidentally we may say, and the sensory impressions from skin, joints, etc., which in consequence are stored in memory, are used in future discharges of motor impulses. Precision will depend upon their number and the accuracy of habitual adjustment between them and motor discharges. Clearly, as experimented facts show, exercise (*i. e.*, the frequency with which they are impressed upon the memory) will go far to determine motor precision.

The effects of exercise upon sensibility of skin is brought out clearly by Féré.[2] A subject more or less regularly practiced flexing his fingers singly, moving them in laterally and bringing them separately into opposition with the thumb. Sensibility before and after the experiment was tested by Block's instrument for finding the least pressure of a millimeter square that gives sensation. This test applied to the fleshy part of the thumb and finger tops showed that, on the right hand the thumb had gained 32 per cent. in sensation; the

[1] *Ibid.*
[2] Rev. Philos., Dec., 1897.

index, 15 per cent.; the middle finger, 10 per cent.; the ring finger, 13 per cent.; and the little finger, 6 per cent.; on the left hand, the thumb gained 37 per cent.; the index, 11; the middle, 7; ring, 5; and little finger, 8 per cent.

The development in accuracy of these kinæsthetic sensations with increasing age, has been neatly demonstrated by Dr. Gilbert in his Iowa study.[1] The subject was seated before a table upon which were two points 50.8 inches apart; a pencil in his hand was placed at one end of the line. After carefully noting the distance, his eyes were blindfolded, and he was asked to move the pencil along the board and place it as near as possible upon the other point. Five trials were allowed each subject. Averages of these estimates from 50 subjects of each sex and for each age from 6 to 19, are as follows (the figures give in centimeters the averages for each age of the estimate of the distance, really 50.8 cm.):

AGE.	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Boys.	10.7	31.2	38.1	44.4	46.5	46.7	44.7	46.7	46.5	59.3	51.5	53.1	54.9	57.1
Girls.	12.7	20.3	29.7	31.8	38.9	46.5	41.1	43.2	48.3	46.7	51.1	51.0	52.1	51.5

The progressive development with age is clearly shown.

(4) *Growth in Precision.* Dr. Bryan,[2] with a somewhat elaborate mechanism, tested precision of finger movement as it occurs in executing the motions of writing. He used in the test some 600 or 700 boys and girls ranging in age from 6 to 16. He states in conclusion that, "the most obvious fact which appears is the great gain which is made between 6 and 8. Almost one-half the gain in precision made from 6 to 16, in both 'up' and 'down' writing movements, is acquired between 6 and 8 years. A second test to which Dr. Bryan subjected the same children was that of their ability, with a stylus, to strike a fixed point. An electrical apparatus recorded the approximations of error. The boys' right hand from 6 to 16 years gains in ability 60%; the boys' left hand, 55%; the girls' right hand, 56%; the girls' left hand, 58%. The pubertal period seriously interferes with the growth in maturity and the chief gain is before puberty.

Professor Hancock[3] tested some 160 children, 5 to 7 years, in threading a needle, sitting still, holding arm horizontally, attempting to suppress twitching movements, tapping with the fingers in various orders, tying strings, etc. Mr. Hancock draws from them the following conclusions: (1) Children early learn to make movements involving large movements. They succeed easily in large movements of some degree of

[1] *Ibid.*
[2] *Ibid.*
[3] *Ibid.*

complexity. (The order of development of control is, evidently, body, shoulder, arm, forearm and hand.) (In hand control the index finger differentiates before that of the others.) (2) (Fine and complicated movements are made with difficulty) (3) (Children in normal healthy growth show a lack of co-ordination and control paralleled only by ataxic, choreic, and paralytic patients.)

A test having a similar significance was used by Dr. Gilbert in his study of New Haven children. The subjects were given 10 weights, varying from 82 grammes to 100 grammes by steps of 2 grammes each, but indistinguishable in size. They were given the smallest weight as a standard, and asked to sort out the others which seemed to be of the same weight. The number of pupils tested was 50 for each year of age and sex, from 6 to 17. Dr. Gilbert thus summarizes: "The results show a gradual increase in ability to discriminate from the ages 6 to 13. After 13 there is a gradual falling off of 6.8 grammes (in discriminative precision), and then another gain till 17. Boys and girls, considered together, gradually increase in ability, but when they are considered separately, marked differences of sex appeared."

In the study, previously quoted, bearing upon characteristics of children who made "rapid," "normal" or "slow" progress in school grades under a system of promotion giving freedom to individuality, it is shown that 54 per cent. of the rapid pupils, 39 per cent. of the normal pupils, and 22 per cent. of the slow pupils are strikingly careful and accurate in their writing and drawing exercises; while on the other hand, 11 per cent. of the most rapid, 34 per cent. of the normal, and 59 per cent. of the slow pupils are strikingly careless and inaccurate. From the evidence of this study we must link accuracy on the whole with a maturer mental development as indicated by school progress.)

We may sum up the matter of accuracy: (1) (that as a primary condition which makes accuracy of hand and arm possible, the child must have a matured degree of control under direction of his higher level centers (*i. e.*, voluntary).) The fact that this maturity is not reached, normally, until the ninth or tenth year, renders questionable the efforts of the school to compel accuracy such as is required by the kindergarten, and also by the primary school, in writing, weaving, etc. (2) (That the ability to be accurate in hand and finger movements increases very materially during school ages;) (3) (that accuracy depends indirectly upon the development of the body as a whole, the steadiness of the trunk muscles being as essential as the accuracy of hand or finger movements themselves; (4) (that for purposes of delicate peripheral movements,)

as shown by ataxographic experiments, etc., the child has not a matured power of control until well into the school period, and long after severe school requirements of accuracy are demanded; (5) that the evidence goes to show that the sensory kinæsthetic sensations, essential in psychological theory, for definite voluntary movements are, in general, in a very immature state until eight to ten years; (6) that while the early years of school life are doubtless the period of nascency for finger and hand movements, nevertheless there is evident need of a clear realization of these physiological conditions on the part of teachers, not only intelligently to direct the training of these movements, but also to guard against unhygienic requirements; (7) that there are manifest dependent relations between general mental ability and power of accuracy of hand movements; (8) that steadiness of the trunk or central movements (fundamental) necessarily precedes ability to be accurate in peripheral (or accessory) movements.

In conclusion, some of the more general suggestions of this review may be restated briefly as follows: 1. The brain grows in its finer structures until a late period in life. There has been a failure to substantiate connection of differences in mentality with the differences in gross anatomy of the brain-shape of skull, weight of brain, form of convolutions, etc.

2. The order of development of the independent parts of the physical and nervous system is, as a general principle (subject doubtless to minor exceptions) from that which is oldest in racial history towards that which is most recent; that those portions which are oldest are most fixed, determined, and least capable of modification by present environment, and those which are relatively most recent are most plastic and subject to modification by education and environment. Among the important pedagogical inferences which follow from this principle, the following might be mentioned:

1. That, taking the activities independently, there is an early period in the development of each part or process, when the purpose of education must be to follow the fixed innate hereditary line of tendency, and to allow the racial instincts fullest play of development (fundamental education).

2. That there follows a later period, in an activity's development, when it passes partially out of the fixed control of racial habit, and becomes more plastic to present environment (accessory education).

3. That the order of logical connection of subject matter belongs, educationally, to the period of approximate maturity of an activity's development, and must not be introduced in

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the earlier instinctive period, in conflict with strong evolutionary tendencies.

4. In an extremely loose sense, clearly recognizing the principle that the organism develops by parts, each of which has a different time of beginning its development, a different rate of ripening, and a different period of reaching maturity, nevertheless we may regard the period of infancy as one of predominating nascencies of the oldest fundamental activities largely in control of the lowest level of the nervous system; the period of childhood from two years to puberty as the period of predominating nascencies of the special sense and their association one with the other: the period of adolescence as the period of predominating nascencies of the highest form of associations, *i. e.*, those which have been developed in the history of the human race.

5. The child's hand at the age of commencing school is relatively immature in power of rapidity of movement, strength and precision. Roughly it would seem that at the age of six the child has acquired only about 20 to 75 per cent. of the power at 16 years of age. It is clear that the period from 6 to 10 years is one of extreme nascency.

6. Deficiencies in the structure of the hand and in freedom of its movements are significantly frequent as accompaniments of deficiency in intelligence. The human hand in early childhood needs opportunity for the fullest possible development which in general proceeds from fundamental to accessory movements. This statement is consequently far from justifying many of the systems now employed in the schools which ignore the principle.[1]

[1] The educational writings of Dr. E. N. Hartwell, particularly his report as Director of Physical Training in Boston schools for 1894, are of especial value on this problem. References to his articles will be found in Mr. Louis N. Wilson's Bibliography of Child Study, 1898.

INHIBITION.

By H. S. CURTIS, Fellow in Psychology, Clark University.

It is feared by the writer that the title under which this article appears may prove deceptive; so that those who would not be interested may be led to examine it, while those who might find in it something of interest will pass it by unheeded. Inhibition is used in its widest sense, in which it is nearly equivalent to natural selection. In the first section will be found a summary of the chief facts and theories of inhibition, psychological, biological and neurological. The second section aims to show the influence of one activity upon another and how it is exerted. The third section aims at a psychology of restlessness, especially in children. The fourth section shows the relations of the foregoing facts and conclusions to pedagogy.

If the standpoint seems materialistic at times, it is because we are dealing with the material side of the phenomena.

HERBART.

For Herbart the whole story of psychology is the story of the struggle of concepts for the possession of consciousness.

The strong concepts drive out the weak; "but as soon as the hinderance yields, the concept by its own effort will again make its appearance in consciousness." "When a sufficiency of opposition exists among concepts, the latter are in equilibrium." The laws of the movement and equilibrium of concepts can be calculated by mathematics. The first law is, "In the case of two concepts, one never entirely obscures the other." "In case several concepts strive together, the sum of arrest will be equal to the sum of the weaker members," etc. No concept which has ever been in consciousness is ever lost, but remains forever at its threshold, waiting to rush back to its old place. The mechanical threshold is the line which separates the conscious from the unconscious. Those concepts on the mechanical threshold, while "out of consciousness, are still effective therein." "But concepts on the statical threshold are in a state of complete suppression and cannot effect consciousness at all. If the concepts on the statical threshold acted in the same way as on the mechanical threshold, we should find ourselves in a state of the most intolerable uneasiness, or rather the body would be subjected to a condition

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of tension that must in a few moments prove fatal. Even as under present conditions, a sudden fright will sometimes cause death; for all the concepts, which, we are accustomed to say, the memory preserves and which, as we all know, can, on the slightest occasion be reproduced, are in a state of incessant striving to rise; although the condition of consciousness is not at all affected by them." There are never more than three or four concepts at the mechanical threshold at once, while the number on the statical threshold may be infinite. The distance between the statical and mechanical threshold is represented by the subconscious modification a suppressed idea has to undergo before it actually enters into consciousness. The movements and struggles of concepts account for all mental phenomena. "Feeling and desiring are conditions and for the most part changeable conditions of concepts." "When a concept is driven forward and at the same time held back, it is the source of an unpleasant feeling." As often as the opposing concepts, which stand in the way of longing, attain preponderance, they produce a painful feeling of privation." "Pleasant feelings must be regarded as springing from the relation of many concepts, which do not arrest themselves individually, but rather which, perhaps for psychological reasons, cannot be perceived when separate." "This favoring (of concepts) is part of the process which takes place in consciousness, but in no way is it anything represented or conceived. Hence it can only be called a feeling—without doubt a pleasant feeling." "In general, it may be observed that feelings and desires have not their source in the process or act of conception in general, but always in certain particular concepts. Hence there may be at the same time many different feelings and desires and these may either agree or entirely disagree one with the other."

"The basis of the reason is the coincident operation of several complete series of concepts." "Will is effort accompanied by the idea of the attainability of the object of effort." "Freedom of the will is the assured supremacy of the strongest masses of ideas." Friendly concepts unite into apperception masses and resist the entrance into consciousness of concepts antagonistic to them. Sanity is the equilibrium of concepts.

Herbart's psychology contains three chief ideas; prevailing ideas are the content of consciousness; defeated ideas tend continually to return; the prevailing ideas tend to ally themselves with all friendly ideas, as men are united into nations or the aggregate of cells makes up the individual body.

In his metaphysics of substance, Herbart says: "But the contradictions contained in the conception of a thing with

several attributes forces us in order to free the conception of these contradictions, to complete the conception by the assumption of the existence of a plurality of real essences, each possessing an absolutely simple quality." Again, "There is no original internal change in what possesses being; hence it must be possible to explain change without the supposition of an original internal activity." The seeming changes are merely the self preservations of the reals. In his metaphysics of the ego, he says, "The soul is a simple essence, not merely without parts, but also without any kind of diversity or multiplicity of quality. It has no time relations. It has no innate natural talents, either for the purpose of receiving or for the purpose of producing. It is therefore no *tabula rosa* in the sense that impressions foreign to itself may be made upon it. It is not a substance which includes in itself original activity. It has originally neither concepts or feelings, nor desires. It has no predispositions to any of these. The simple nature of the soul is entirely unknown and will forever remain so." "The self preservations of the soul are concepts, and indeed simple concepts, for the act of self preservation is as simple as the essence, which is preserved."

I, for my part, can see no way of harmonizing Herbart's empirical and rational psychology; or how he can speak of an ego, which is a "simple essence," "without innate faculties or predispositions," totally unknown and unknowable, of which ideas are the "self preservations" (or reactions), and say also that "the content of consciousness is determined by the struggle of the concepts" and that "ideas rise by their *own force* from a state of complete suppression," etc. Concepts seem to be independent real beings, each one struggling for as large a share of consciousness as it can gain. His laws of the movement and equilibrium of concepts are only familiar laws of evolution in another form. When the concepts which repress a given concept decrease, the concept rises into consciousness, or into a fuller possession of consciousness; so, also, when the concepts, which favor a given concept, increase, this concept comes forward into greater prominence. Again, when the concepts which favor a given concept diminish, or concepts antagonistic to it increase, it sinks down to a lower level. These laws are identical with the laws for the equilibrium of the animal with its environment. When its enemies decrease, or when the conditions which favor it — as food water, etc., increase, the species becomes more numerous. Conversely, when its enemies increase or the conditions which favor it diminish, the species is reduced in numbers.

But, whether consistent or not, Herbart's empirical psychology certainly describes very well the actual events of con-

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sciousness. We all know how the child forgets the old toy in the new ; and how new interests, loves, hopes, and fears are continually driving out their predecessors, and being in turn driven out by those which follow them. It emphasizes above all the economy of a monoideistic state of consciousness. Its interest for us is, that it shows a form of intellectual inhibition, which is practically equal to the "struggle for existence." It is inhibition by individuals rather than by central control.

Herbart's doctrine of apperception and his doctrine of interest, which depends on his doctrine of apperception and feeling together, have justly had great influence in modern pedagogy.

Beneke.

The system of Beneke derives much from Herbart, and leaves out most of its inconsistencies. It is rather confusing at first, because it is hard to see just what he means by the original (psychic) power, on the stimulation of which all psychic products depend. Perhaps capacity of reaction of the nerve cell ; as of sight in the visual area, sound in the auditory, etc., would best describe these original powers. Every idea leaves a trace behind in the original powers, and when this is again stimulated either from within or without, the idea is brought again into consciousness. These traces he calls "formed primitive powers." Each faculty is only a summation of all the soul's acts of a particular kind, according to the law that "all products of a like kind attract each other, and as a consequence fuse into a whole." He says : "We give the name of understanding to the totality of concepts existing in the soul ; judgments to the totality of judgments ; inferential power to the totality of conclusions ; will to the totality of all ready formed acts of willing ; consequently the faculty of feeling is nothing more than the totality of all the feelings that arise in the soul, and are permanently existent in it." "The developed human soul is a product of simple original powers and of that which has affected them and been permanently retained by them." "For all our powers of sense, together with the products springing from them, form one intimately connected whole ; *they are the soul.*" It will be seen that Beneke has dropped Herbart's transcendental ego and made use of his doctrine of apperception to explain the faculties of the soul and the soul itself.

Taine.

For Taine, as well as Herbart, all mental events are determined by the mutual struggle of ideas ; though Taine takes the further step of reducing all ideas to sensations, and showing us somewhat more definitely how this takes place. He says :

"The ordinary image, then, is not a single but a double fact. It is a spontaneous consecutive sensation, which, by conflicting with another sensation, primitive and not spontaneous, undergoes lessening restriction and correction. It comprises two momentary stages, a first, in which it seems localized and external, and a second, in which its situation and externality are lost. It is the result of a struggle, its tendency to appear external is opposed and overcome by the stronger and contradictory tendency of the sensation, occasioned at the same time by the action of the nerve. Under this effort it grows weak and thin, it is reduced to a shadow, we call it an image, phantasm, or appearance." "The mutual arrest, the reciprocal clash, the repression, produce by their combined effect an equilibrium. This equilibrium is a state of reasonable wakefulness. As soon as it is at an end by the hypertrophy or atrophy of an element we are mad, wholly or partially." Thus, "all circumstances, which suppress or diminish the corrective sensation, facilitate or provoke hallucination." And, "all circumstances, giving rise to or augmenting the corrective sensation destroy or weaken the hallucination. If we approach a person suffering under a hallucination of hearing, and speak to him so as to fix his attention, we can convince him that his pretended invisible interlocutors are silent while the conversation lasts." "Every image is possessed of an automatic force, and tends spontaneously to a particular state, to hallucinations, false recollections and other illusions of madness."

All the psychic life can be reduced to sensations. "All that observation detects in the thinking being are, in addition to sensations, images of various kinds, primitive or consecutive, indued with certain tendencies, and modified in their development by the concurrence or antagonism of other simultaneous or contiguous images." "Just as the living body is a polypus of mutually dependent cells, so the active mind is a polypus of mutually dependent sensations and images; and in the one case as in the other, unity is nothing more than a harmony and an effect. The ego is a mere abstraction; all, that is, is the individual sensation, idea, or image, which may occupy consciousness at the time. As Condilac has said, 'when I smell a rose, this sensation is all my ego.'"

Sensations may be still further reduced to molecular movements in the brain cells. There is no mental product without molecular movement. There is no molecular movement without some mental result, though this may be subconscious. Molecular movement and sensation are really the same thing, and the reason they do not seem so, is, because we see them from opposite sides.

The most important point in Taine's system is: that the ele-

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ments of consciousness, sensations and images, if left to follow their inner tendencies, would make a pandemonium of the human mind. It is only through their mutual checks and repressions that sanity results.

Roux.

Just as Herbart and Taine have sought to account for all psychic phenomena by the struggle of ideas, so Roux has sought to account for all physical phenomena by the struggle of the parts (Kampfe der Theile). He thinks we do not need to suppose a special organizing principle, which builds the body after its own ideal; but just as evolution has gone upward to higher forms through the mutual antagonism of the organisms concerned, so the struggle of the molecules, cells and tissues determine the animal body. The battle is just as fierce and selection just as rigid between the cells of the same organism, as between different organisms in the external world. He begins with the molecules. Those are established which have the strongest power of attraction and assimulation, by which they get the start of the others and retain it. In the struggle of the cells, those cells which get started first, occupy the space the others would fill, and the strong take away the food from the weak, so that they are ultimately eliminated. Those cells which are most often stimulated to functional activity are over compensated for their waste, and are thus victorious in the struggle.

In the struggle of the tissues and organs we have the same process repeated. Even the form of the various organs is largely determined by their neighbor organs. If any one tissue should become so strong as to take all the nourishment, the organism must die. Health is the equilibrium in the struggle of the parts. The activity of any tissue is not due to its hyperemia, but its hyperemia is due to the increased assimulation of its cells, caused by the stimulus. The result of this is two fold the increased nourishment and enlarged blood vessels of the part used, and the diminished nourishment and shrunken blood vessels of the parts unused. Through the activity of this inner struggle adaptation is carried down to the last molecule of structure; as parts which do not function atrophy and disappear from lack of stimulus. Roux sums up the results of his theory as follows: "Those cells or cell parts will be established, which are in the position to bring on functional adaptation, and this is the result of the struggle of the cells." "On the other hand the struggle of the different organs and tissues among themselves leads to the greatest possible utilization of the space in the organism; to inner harmony; to the perfection of the physiological significance of the parts to the

corresponding morphological significance." "Through this struggle a much more perfect adaptation to ends must be brought about, and much quicker, than according to the Darwinian principle of the selection of formal variations among individuals." This view presupposes the same conditions in the body as exist in the external world, namely, that there are germs of many more cells in the body than can possibly find place there and a consequent struggle for room; and that the amount of food is always limited, and the high nourishment of some means the low nourishment of others.

It is seen at once, that this is only another application of the general theory of evolution. It seems absurd to think that anything so definite as the bodily form should be determined by such seemingly chaotic forces. But on consideration we see that the result of the struggle is really predetermined by its conditions; as tissues must prevail in proportion as they are used. It will be seen that this question is at bottom the old question: is the animal body a unity, or is it a colony of cells? No one would claim that it is a unity in a strict sense, neither can any one claim that it is a mere aggregate of cells, such as we see in lower forms. So the question remains, how far has the process of unifying gone? How much of its liberty does the individual cell surrender to the cell community and in how far is it only a specialized member of a socialistic state, still retaining all its selfishness and simply bartering products for its own advantage?

Here we cannot refrain from following a little further the analogy between the individual and the race. Has not the course of the two been parallel in this as in other things? The savage is the single cell. Each individual is independent and unspecialized, absolutely selfish in his acts. With life in a herd or tribe the preservation of the aggregate becomes the important thing, in which the preservation of the individual is contained. The individual begins to form a consciousness of the whole and selfishness of the whole for preservation against its enemies. This process is still going on. Closer communication, better knowledge, and common interests are drawing men closer every year. Specialization is destroying their independence. Society is *becoming* an organism. With this organism must we not postulate a consciousness of the whole which would find its rude beginnings in the social instincts, and of whose higher development, perhaps, telepathy is a nascent faculty? The analogy would lead us to suppose that this process must increase until each individual becomes a ganglion cell in the brain of humanity and common sympathy and interests unite all. The law of love is the sure outcome of the law of evolution. If we glance back at the evolution

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of the individual, must we not suppose the aggregate of cells became an organism in very much this way? First acting singly and independently, ultimately coming to act together and forming a common consciousness; in which the consciousness of the individual cell is lost, though it may be retained for itself.

In the vegetable world the "kampfe der theile" seems to be yet more apparent. Each twig and leaf struggles for space and sunlight as best it can. The upper branches overshadow the lower and they dry up and drop off, just as unused members atrophy and disappear from the animal body. Each spring a twig starts from beneath the scar of each old leaf along the branch; but, if you look again after a year, you will find scarce one in a dozen has survived. Only those that have found or won space and sunlight are left. The length of the leaf stalk and size of the leaf are determined by their relations to the sunlight.

The Vagus.

Despite the immense amount of investigation to which the vagus has been subjected of late years, its function is still far from clear in details. I am aware of the hypothetical nature of much that follows. But there seems to be sufficient evidence for certain probable conclusions.

The ordinary phenomena, seen in the stimulation of the vagus are: that the heart is slowed or stopped after the first or second beat and held thus for a few seconds,[1] when it begins to beat again and beats more strongly than it did before stimulation. Of late, however, the most or all of this secondary augmentation has been referred to sympathetic fibres, bound up in the same sheath with the vagus. The action of the vagus varies greatly at different times. With many investigators you cannot tell whether the combined nerve (vagus and sympathetic) or the vagus alone was stimulated.

Gaskell has made very extensive contributions[2] to this subject, working chiefly on the frog and turtle. He holds that the vagus is the trophic nerve of the heart, its action resembling that of a stimulus, too weak to produce motor effects. Every modification of the beat, due to vagus stimulation, can

[1] It may last for a day or more in the turtle.

[2] Journal of Physiology, 1880-1, p. 48-75.
" " 1880-2, p. 369-379.
" " 1881-2, p. 199-203.
" " 1883 p. 43-127.
" " 1886 p. 451.
" " 1887 p. 404-415.
Brit. Med. Journal, 1882 p. 572.

be paralleled by the action of a blood solution on an exhausted heart.

"If a salt solution be passed through the heart and afterwards a blood solution be sent into it under the same conditions of pressure as the salt solution, then it often happens, that as soon as the blood solution is seen to reach the heart or the ventricle of the heart, it stops still in the relaxed condition, sometimes for a considerable length of time and subsequently begins to beat again with an improved beat, due to the blood solution. In the same heart this experiment may be repeated again and again. In other hearts the sudden supply of nutrient matter does not cause any stoppage, but simply a gradual improvement in contractions."

Gaskell's earlier work was done on the combined nerve. But in his later contributions he still affirms the trophic function of the vagus.[1]

[2] Wesley Mills studied the acceleration of the heart in the slider terrapin, from section of the vagus. It may rise from 12 to 25 beats per minute, but depends on the condition of the heart at the time.

[3] McWilliams found similar results upon warm blooded animals. "After augmentations are slight and variable in character."

[4] Howell says the theory of the trophic action of the vagus has "commanded most attention" of recent years. These inhibitory impulses "may be discharged by the continuous stream of afferent impulses that constantly play upon them from the multitude of afferent nerves.

This later theory, the conception of a reflex tonus, is made probable by the observation, that section of the vagi does not increase the heart beat after the greater part of the afferent impulses have been cut off by section of the spinal cord near its junction with the bulb, and that the sudden decrease in the number of afferent impulses, caused by the section of the sphlancnic nerves, quickens the pulse rate." Eichorst[5] and Zander found "that the death which results from the section of both vagi, is not entirely due to inanition, but partly to degenerative changes in the heart itself." They conclude: "The vagi exercise a trophic influence upon the heart."

Fontino cut a section a cm. in length from the left vagus of

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[1] Journal of Phsyiology, 1887, VIII, p. 415.
[2] Journal of Physiology, 1885, VI, p. 246.
[3] Journal of Physiology, 1883, IV, p. 367.
[4] American Text Book of Phys., 1896.
[5] Die teophuchen Bezuhungen der Nervi Vagi zum Hertzmuskel, Berlin, 1879. (I am not quite sure of this reference.)

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a rabbit, after which he allowed the animal to live for several days. The animal seemed still in good health, and ate well, the other organs were found in good condition on being examined, but the heart was very much atrophied.

Ried Hunt has been one of the most fruitful laborers in the field of late. In his first[1] article he gives a very careful study of the results from stimulating the vagus and accelerator nerves separately and simultaneously. The section of the accelerators slowed the heart rate, their stimulation increased it. But the heart escaped from this acceleration more quickly than from vagus inhibition. When both nerves were stimulated together, the result was practically the algebraic sum of stimulating them separately. He worked upon the dog, cat and rabbit in his chief research, but found the same results in the crab. He found a slight after augmentation from the stimulation of the vagus alone in some cases. He inclines to the view that the accelerators are katabolic and the vagus trophic in function. [2]In two more recent studies by Ried Hunt and Harrington on the vagus of the opossum and the calf, they find the effect of the stimulation of the vagus of the opossum pronounced and long continued, with no after acceleration ; though there was sometimes an increase in blood pressure. In the calf[3] there was an after acceleration in two cases.

[4] Harrington, in a study of the cardiac nerves of the guinea-pig, found that the blood pressure usually rose above normal after stimulation of the vagus, and that there was an occasional after acceleration.[5] But he thinks the efficiency of the heart was lessened, and questions the trophic function of the vagus.

It will be seen that our knowledge of the vagus is not yet altogether satisfactory. That it inhibits the heart seems certain, as its rhythm is accelerated on the section of the vagi, and retarded by their stimulation. That it has something to do with the nourishment of the heart seems very probable ; inasmuch as the same stimulus will not repress the heart for long at a time, and there is often a secondary augmentation ; sending a blood solution through the heart after a salt solution has the same effect ; if the vagus is cut and the animal allowed to live the heart atrophies, although with the vagus intact the animal may be starved to death without this occurring. But it seems unreasonable to suppose that the heart alone should have a special apparatus for nourishing or inhibiting it, or that a nerve impulse should cause nutrition in one case and contrac-

[1] Jour. of Ex. Med., March, 1897.
[2] Jour. of Ex. Med., Vol. II, pp. 715 and 725.
[3] P. 725.
[4] Am. Jour. of Phys., Vol. I, No. 3, p. 339.
[5] P. 392, in the dog 389 (frequent).

tion in another. Still we know that the lungs and intestines also have nerves, whose actions resembles that of the vagus.

Is there not a good basis for the belief that every nerve stimulus is trophic? Wundt says every sensory stimulus first causes nutrition, and nutrition inhibits activity for a time. There seems to be good evidence also that nerve cells[1] and muscles[2] atrophy without their proper stimuli.

WUNDT. "Mechanik der Nerven."

This work of Wundt on the mechanics of the nerves does not seem to have received as much attention from neurologists as the eminence of its author and the great carefulness of his investigations deserve.

He has sought to reduce nerve phenomena to terms of physics and chemistry so far as possible. The nerve stimulus is the potent factor in nerve growth, activity, and inhibition of activity. The first effect of every stimulus is the nutrition of the cell. The nerve stimulus is turned into a growth force. By this means it is made latent in the fiber for about one two-hundredth of a second, and for a somewhat longer period in the cell. The albuminoids and fats are torn down, and the nerve molecules are built up to higher and higher complexity. These molecules are like a child's block tower, built up higher and higher until with the last block it all tumbles down, and the force, that was expended in building them up, is liberated in the force of their fall. Just as the fall of the pile driver liberates the force which was stored up in raising it — to use Dr. Hall's illustration. This process of building up compounds to greater complexity is the only way in which energy is stored in the nervous system, as the tearing down of complex molecules is the only way energy is set free. This process of storing up energy is going on continually, alike from perceptible and imperceptible stimuli. The process is slow or rapid, according to the intensity of these. As a result there is a constant tendency to build up these molecules higher than they can endure, and a consequent rhythmical overflow in muscular movements. But this surplus is constantly being "drained off to points of lower tension,"[3] and so "the equilibrium maintains itself." If this overflow is prevented in any way, the critical point may be reached by even minimal stimuli, and an explosive conduction takes place. Minimal stimuli carry on the activity of the heart and lungs by a summation process. Sensation is the mental equivalent for the resistance of the cen-

[1] Donaldson: *Am. Jour. of Psy.*, Vol. IV, p. 282. Growth of the Brain, p. 268.

[2] Stewart: Manual of Phys., p. 546. Brain, Vol. LXXX, p. 536.

[3] Second part, pp. 141 and 142.

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tral substance, by which stimuli are made latent. There is no real difference between sensory and motor cells, their difference of action depends on their relations to the nerve endings.

Wundt's system contains two very important principles: that the nerve stimulus is nutritive and inhibitive, and that nerve energy tends to equalize itself by overflow from points of higher to points of lower tension.

Setschenow[1] thought he had discovered the inhibitory mechanism for the spinal cord in the optic lobes.

Goltz,[2] after repeating the experiments of Setschenow concluded there were no inhibitory centers, but the entire brain and sensory nerves served this purpose. "The tonic activity of higher centers represses the activity of lower ones."

In as much as there are said to be no special inhibitory nerves the cells of the cord must be inhibited through the pyramidal fibers and sensory nerves that reach them. We have evidence of the constant influence of the brain over the cord,[3] in variation of reflexes, knee jerk,[4] secretions,[5] etc., with different emotional and intellectual states. If this means that minimal stimuli are constantly passing downward to the cells of the cord, we may expect this excitation to interfere more or less with other stimuli from the sensory nerves to the same cells. So, also, there may be a greater tendency for stimuli to pass up the cord,[6] when the brain is intact, and thus weaken the reflex stimulus.

It seems like a great waste of energy if nerve cells have to be restrained from action continually. But, if we accept the view that this restraint is only nutrition, this objection disappears.

II.

In the pages which precede, I have treated in a historical way, the current theories and facts of inhibition. In the pages that follow I shall seek to show what is the effect of "the struggle of the parts" as applied to activities.

In general, activities repress one another; the store of energy at the command of the organism is always limited, and the using energy in one way must prevent its use in another.

Dr. Sargent[7] represents the amount of force expended by an average man weighing 150 pounds at 3,400 foot tons daily.

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[1] Hemmungs Centren des Frosches.
[2] Beitrage zur Lehre von den Functionen der Nervencentren des Frosches, Berlin, 1869.
[3] Howell: Am. Text-book of Phys., p. 655.
[4] Lombard: *Am. Jour. Psychol.*, Vol. I, p. 5.
[5] Binet and Henri: La Fatigue Intellectuelle, p. 332.
[6] Setschenow: Hemmungs Centren des Frosches.
[7] North American Review, May, 1897.

He divides this expenditure among the various activities as follows:

Colorific work,	2,840 foot tons.
Internal (nervous and vital) work,	260 " "
External (muscular) work,	300 " "

If these estimates are correct, then several inferences may be drawn, if all these activities draw on a common store of energy. If we suppose the capacity of the individual for continuous work is 3,400 foot tons, the requiring of 400 tons in muscular work, instead of 300 tons, would only leave 3,000 tons for nervous and vital processes. Thus a demand upon any one of these activities beyond what nature is prepared to furnish by an increased nutrition, must be drawn from the others.

Let us see how well this supposition agrees with the facts. To begin with muscular work. There is a limit up to which increased exercise brings increased strength of the muscles concerned. The muscles increase in size and the bodily condition is improved, beyond this an increase of exercise diminishes the strength of the muscles and lowers the condition of the body. I am not aware that any one has given us the criteria for judging where this point is. But such a point must exist for every activity. In terms of force this would be the point where the energy consumed is greater than the energy produced. Up to this limit the stimulus of exercise is beneficial to muscles and nerve cells and causes them to produce a greater amount of force, beyond this limit it is injurious, the waste exceeds the repair and the general tone is lowered. Thus we come up everywhere against human limitations. Not he who works hardest achieves most, but he who works at his maximum of power, a point of great importance for every one to determine for himself. But sometime before the point is reached that the activity concerned is weakened, it begins to draw on the supplies of the other activities. Just as the heart and brain will starve the rest of the body and still be undiminished themselves, so it seems to be nature's law *that active parts shall be fed at the expense of inactive ones if necessary, or even at the expense of parts active in a lower degree.* Sargent says: "Porters, draymen, heavy iron workers, and a certain class of athletes often illustrate the effects of an excessive use of the muscular system. Where the body's nutriment is expended in this direction, the impairment of the heart and lung tissue is likely to follow."[1] Again, "It is possible to develop the muscular and nervous systems to the detriment of the

[1] North Am. Rev., May, 1897, pp. 558-561.

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heart, lungs and digestive systems." I understand that the impairment of the heart and lungs is a common result of the overtraining of athletes.

When a child is growing very fast he is disinclined to exercise. Reversely, too much exercise will probably check growth. Starvation certainly will, and the excessive use of one would starve the other tissues. The small size of factory children is possibly a composite result of these two elements.[1]

But the effects on the brain are most disastrous of all. The children whom I have known to be set to work at seven or eight, and worked hard, have grown up very dull. "All work and no play makes Jack a dull boy." Scholar comes from σκωλή. Intellectual workers are usually incapacitated for hard work by severe exercise.[2] It is a common experience of the students here, that, if they play three hard sets of tennis in the afternoon, they cannot work afterward. I often notice the full effects in myself. I fall back into automatism and habitual movements. On coming up to my room, I am apt to enter my old room across the hall, although I have not occupied it for nearly a year. On sitting down to write, I often dip my pen in the old empty ink bottle instead of the new one and date my letters in the last month. I often lie down and usually drop off to sleep almost at once. All of these are phenomena of suspended mental activity. The sound sleep of laboring men is one of the surest proofs that their work has drawn on the brain severely; for if the brain had been inactive during the day, its cells would be highly nourished and very excitable at night, so that sleep would be impossible. Mental activity certainly cannot account for much of this.

Mosso[3] gives many examples of the effect of physical fatigue on mental ability. He says he has climbed Mount Blanc several times, but he can remember nothing of the view from the summit. He has a friend who is a famous mountain climber, but he finds it necessary to write down his impressions as he goes along, for nearly everything has gone from his mind before he has completed the descent. He also mentions the case of a botanist who has taken a long trip into the country and obtained many interesting specimens, but finds himself unable to classify them until he has rested. Muscular work even in moderate amounts seems to diminish the rate of the tapping[4] and reduce the speed of mental calculations.[5]

The data is not at hand for making any very definite state-

[1] Burk: *Am. Jour. of Psy.*, Vol. IX, pp. 272-278.
[2] Spencer: Education, 269.
[3] Die Ermüdung, p. 201.
[4] *Am. Jour. of Psy.*, Vol. IV, p. 52. Dresslar.
[5] Binet and Henri: La Fatigue Intellectuelle, p. 278.

ments about the effects of increased heat requirements on the other activities. In general, the extra expenditure is nearly made up by an increased metabolism. But, if exactly the same amount and quality of food were eaten in winter as in summer, the organism certainly could not do as much work in winter. If breeders wish to produce a very small specimen of any species, they cause it to be born late in the fall and keep it in a cold place. Races, who live in polar regions, are often undersized and attain their growth and maturity later than people of warmer climes.

Intense cold produces an intellectual lethargy, complained of by arctic explorers. There is a tendency to go to sleep. "Down has observed that in England, idiots lose in winter the few acquirements they have been able to make in summer when there is least tax on their poorly nourished bodies."[1]

Sexual indulgences may check growth in the undeveloped.[2] It causes male animals to remain lean in the mating season. It causes a physical weakening so that athletes are usually forbidden intercourse with their wives during training. Excesses may lead to derangement[3] or if very great to imbecility.

Woman[4] has such severe drains upon her energy through the menstrual flow and child nourishment that in physical and intellectual achievement she has ever been the inferior of man. She may not be inferior in capacity, but she is in ability to endure protracted labors.

The effect of excessive brain activity is most disastrous of all. Spencer says[5] the present race of Englishmen are inferior to their fathers in height, weight and resistance to disease. He thinks the overwork of the school children is the cause. He says this belief has been thrust upon him by observing the constant physical break-downs in over-pressure schools. For every one that breaks down, there must be at least halfa dozen injured, he thinks.

Mitchell,[6] after commenting on the sad state of health of the American girl, lays the blame to the schools. He says: "I firmly believe, and I am not alone in this opinion, that as concerns the physical future of women, they would do far better if the brain were very lightly tasked, and the school hours but three or four a day until they reach the age of 17 at least."

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[1] Donaldson: Growth of Brain, p. 296.
[2] Dr. Hall: Adolescence.
[3] Dr. Hall: Adolescence.
[4] Havelock Ellis: Man and woman, pp. 256-257. Curves on page 249. See also *Ped. Sem.*, Vol. III, pp. 468-482.
[5] Education, p. 260.
[6] Wear and Tear. Compare, also, Rankin Hygiene of Childhood, p. 115.

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There is a good deal of more or less experimental evidence to show the influence of brain activity on the various bodily and vital functions.

That growth may be checked is difficult of proof. Still it appears that children grow faster during the summer vacation.[1] On this point European statistics seem to be agreed.

Binet and Henry, after careful study of the boarding schools of France, conclude the weight of the children may be actually diminished by excessive brain work.[2]

Mosso,[3] after speaking of how the other tissues are consumed to supply the heart and brain in death by starvation, and the effect of severe brain work on the strength of the muscles, says: "And therefore I hold it for probable, that not only by starving, but also by exhausting the brain by excessive work, the muscles may give up a part of their albuminoids to the blood currents to be carried to the brain." I notice in my own case that I grow lean when I am working hard, and begin to gain flesh with a vacation.

Mosso[4] and Binet[5] both found that a brief period of intellectual activity increased physical strength, but a long period reduced it. Dr. Maggiora[6] tested the strength of the middle finger of his right hand on the ergograph in the morning, 40 contractions, amounting to 5,694 kilogrammeters. At 5.15, after examining 19 candidates, he could only make 11 contractions, amounting to 1,086 kilogrammeters. Mosso says: "The tiring the brain diminishes the strength of the muscle." "The requirement for rest after a period of severe mental work rests on the fact that the nerve centers are depleted and the muscles are weak."

Binet and Henri[7] found that hard mental work began to reduce the rate of respiration after 15 minutes, and of the heart beat after half an hour. Spencer[8] says this result may become permanent as the result of overwork.

There seems to be a general agreement that dyspepsia[9] may be caused by excessive brain work, and the resistance to disease lowered. I find that I have to be more careful when I am working very hard.

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[1] Vahl, Malling Hansen and Schmidt Monard, as quoted in La Fatigue Intellectuelle, Binet and Henri, 1898, p. 221.
[2] La Fatigue Intellectuelle, p. 224.
[3] Die Ermüdung, p. 285.
[4] Die Ermüdung, pp. 278–280.
[5] La Fatigue Intellectuelle, p. 167; résumé, p. 195.
[6] Die Ermüdung.
[7] La Fatigue Intellectuelle, p. 332.
[8] Education, p. 274.
[9] Spencer: Education, p. 274; Sargent: N. A. Rev., May, '97, pp. 558 and 559; Cowles: Neurasthenia, p. 52.

Inasmuch as the function of sleep is mainly brain rest, we may expect the same results from loss of sleep as from excessive brain work. Rankin says: "Insufficient amount of sleep (in children) often results in smallness of stature, stunted growth, and in insanity in later years." Again: "The symptoms resulting from too little sleep are nervous irritability, restlessness, loss of flesh, and a delicacy of digestion."

In experiments carried on in Italy it was found that dogs could be kept without food for 20 days, and lose more than half their original weight and still survive; but loss of sleep for four or five days proved fatal. The temperature fell as much as 8° below the normal at the last.[1] If a hibernating animal wakes up too soon it is apt to starve to death.

In what we have said thus far we have spoken as though the energy for all the activities was drawn from a common reservoir, into which exactly the same amount was poured each day; so that any excess of use in one direction meant a deficiency in some other direction. We have seen that these suppositions agreed fairly well with the facts. Still the case is by no means so simple as this. All activities increase the metabolism so as to compensate for the extra work up to a certain limit, or even over compensate it. Beyer[2] has shown from the measurement of naval cadets that the height may be increased one inch, and weight 50 to 60 pounds, by systematic exercise, during the years from 16 to 20. Years in which gymnastics were taken being compared with years in which they were not taken.

We must not confuse the ultimate and immediate effects of any activity, however. Severe physical exercise may incapacitate us for mental work in the evening, but be of great assistance the next day. So long as an increased expenditure is compensated by an increased supply the use of one activity may *ultimately* strengthen all the others.

How then does one activity influence another? There are at least four important ways: First, the toxic products of the waste of muscle or brain are constantly cast into the circulation, whereby all parts are affected. "If[3] the muscle vein is tied and the waste products ordinarily drained off are kept within the muscle, its irritability is lowered. It may be brought again into healthy action, by furnishing it a fresh supply of healthy blood, by washing[4] out the waste materials, or allowing it to rest." Mosso[5] found that if the blood or pul-

[1] Manaccene: Archiv Italien de Biolog., XXI, '94. Quoted in Revue Scientifique.
[2] Jour. of Ex. Med., Vol. I, p. 546.
[3] Taine: Phys. Education.
[4] Donaldson: Growth of Brain, p. 311.
[5] Mosso: Die Ermüdung, p. 119; Cowles: Neurasthenia, pp. 36 and 38.

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verized muscle of a fatigued dog were injected into a normal dog the normal showed all the symptoms of fatigue.

[1] Similar waste products are probably produced in a fatigued brain.

Secondly, the continued activity of one organ causes dilatation of its blood vessels. This means a diminution in the blood supply to other parts. The food materials are extracted from the blood more actively by functioning parts, and as a result it is poorer in food materials for other organs.

Thirdly, useful materials may be actually taken from resting parts to feed functioning ones, as Mosso[2] has said. He instances the migration of the salmon up the Rhine. It does not eat, but the main mass of the fish is made over into roe on the journey. The wasting of the tissues in starvation is another example of this. This effect would be noticed only when the demand on a tissue exceeded its food supply.

Fourthly, the motor areas for setting off all the activities may be connected so that the exhaustion of one may weaken the others. Probably these factors[3] enter into different states of fatigue in varying degrees.

In every muscular movement there are three factors involved: the muscle, the nerve, and the nerve cell. It seems to be well established that the nerve[8] itself does not tire, but the muscle or nerve cell may be fatigued. To this fatigue there are two elements: that due to loss of energy,[4] and that due to clogging by waste products. As a rule the nerve cell seems to fatigue[5] first; as a muscle, which can no longer be contracted voluntarily still responds for some time to the electrical stimulation. The importance of the nerve cell to physical strength is much underrated in most estimates. If the nerve cell is injured the muscle lies inert, and soon atrophies.[6] Now I raise a feather in my hand, and now I raise a hundred pounds. What makes the difference in the tension of the muscles? It can only be caused by the strength of the impulse the muscle receives.

A man in fright or delirium[7] may exert twice his usual strength. I have noticed that in exhibitions I can sometimes draw myself up on the bar with one hand, which I cannot do at all at other times. We cannot well suppose that the *muscles* are stronger at such times. It has been shown that students[8]

[1] Donaldson: Growth of Brain, p. 313.
[2] Mosso: Die Ermüdung, p. 283.
[3] The nerve plate may be fatigued.
[4] Hodge: Jour. Morph., Vol. VII, p. 95; Stewart: M. Phys., p. 542.
[5] Donaldson: Growth of the Brain, pp. 312 and 322.
[6] Stewart: Manual of Phys., p. 546.
[7] La Fatigue Intellectuelle, p. 181.
[8] Tests at the Yale Laboratory.

have a stronger hand clasp than laboring men; although they have probably done very little to develop it. It is also well known that the strength varies with various conditions. As has been abundantly shown any sensory stimulus may greatly augment the knee[1] jerk or the pressure on the dynamometer,[2] if it occurs at the right time. General cerebral excitement profoundly influences all these. The [3]knee jerk, rapidity of tapping,[4] and power[5] of clasp are all increased by brief intellectual activity. But intellectual fatigue again reduces them below the normal. In a series of experiments, which I carried on last year, strength seemed to be in a very close relation to mental excitement. Normally I could press from 115 to 120 pounds. But on one occasion, after working for an hour and a half on my thesis and getting very much interested, the average ran up to 127,[6] with 132 as the highest contraction. As similar results were obtained by Binet and Henri, I refer to them instead of treating more of my own results. These facts show the close dependence of physical strength upon brain states. Another set of facts prove that more than the motor area directly concerned are drafted in at any rate.

The rate of tapping[7] and strength of clasp[8] of one hand is reduced by tiring the other previously. Each hand has greater endurance, when worked alone. When both hands are contracted together,[9] the left hand is stronger and the right not so strong as usual. Both hands share the gains from the practice[10] of one. The hemispheres are approximately equal in size and weight,[11] although we use our left hemisphere very much more. Physical strength is reduced but endurance increased by hard brain[12] work at the same time. I can see no satisfactory explanation of these facts but the transference of energy from one part of the brain to another. It is unfortunate that no one has tried to see if tiring the leg would not have a similar effect upon the strength of the hand. But we do know that a

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[1] Lombard: *Am. Jour. of Psy.*, Vol. I, p. 49.
[2] Féré: Quoted by Jones, *Psychol.*, Vol. II, p. 379; Binet and Henri: La Fatigue Intellectuelle, p. 181; Cleghorn: Am. Jour. of Physiology, Vol. I, No. 3, p. 339.
[3] Lombard: *Am. Jour. of Psy.*, Vol. I, pp. 52 and 53.
[4] Dresslar: *Am. Jour. of Psy.*, Vol. IV, p. 521.
[5] Binet and Henri: La Fatigue Intellectuelle, p. 181; Mosso: Die Ermüdung; Lancaster experiments at Clark University.
[6] Five tests.
[7] William Brian: *Am. Jour. of Psy.*, Vol. V, p. 198.
[8] Proceed. of Col. of Phys., Philadelphia.
[9] Binet and Henri: La Fatigue Intellectuelle, p. 181.
Jeannette Welch: Am. Jour. of Phys., Vol. I, No. 3, p. 286.
[10] Dresslar: *Am. Jour. of Psy.*, Vol. IV, p. 201.
[11] Donaldson: Growth of Brain, 275.
[12] Jeannette Welch: Am. Jour. of Phys., Vol. I, No. 3, pp. 291-299.

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vigorous walk reduces the rate of tapping and of mental calculations.[1] When we add to these considerations the results of the ergographic tests of Mosso and others, it becomes certain that the use of one part of the brain may weaken or strengthen the action of other parts according to the length of time it is carried on. Into many of these cases the problem of toxic products does not enter; as the increase in rate and strength of clasp, due to mental activity; as also the increase in strength of left hand, when the right is contracted simultaneously. Let us analyze the simplest of these cases, the exhaustion of one hand or finger by working another. The part involved is so small and the exhaustion may be so speedy, that we cannot well refer the effect on the other hand or finger to toxic products. The lessening of the blood supply or destruction of the tissues of the other hand is not worth considering in this connection. Still it may be said the two hands work together and we actually contract the other hand and hence use both its muscles and its nerve centers. This is true to some extent, but it would scarcely amount to a "warming up," not more at any rate, and hence should increase the muscular power. The only conclusion left seems to be that the nerve centers of one hand were weakened by using the other hand. The motor area for a muscle is the point where the stimuli for that muscle leave the cortex, but it is not necessarily the place where they are generated.

Those who would explain muscular fatigue by mental work, by saying we think with our muscles, must take into account the experiment of MacDougal,[2] who found the finger was relaxed during mental effort, and Binet and Henri[3] who found the muscles of the eye in a similar condition. This theory cannot well account for any increase of strength due to mental activity.

There is plenty of direct evidence for discharges from one brain area to another. Stimuli[4] to a single sense stimulate the entire brain. All sensory and motor areas are under voluntary control. This can only mean discharges from the association areas upon the areas concerned. If this were continuous, there would be mental exhaustion from muscular work. Perhaps this is the explanation of the mental heaviness of laborers. In case of intense mental work the current *may* set in

[1] Binet and Henri: La Fatigue Intellectuelle, p. 278.
Dresslar: *Am. Jour. of Psy.*, Vol. IV, p. 52.
[2] Psychological Rev., March, 1896, p. 158.
[3] La Fatigue Intellectuelle, pp. 170-171.
[4] Donaldson: Growth of Brain, p. 283.
Sensory stimuli increase strength.

the other direction. Motor areas would discharge upon the associational areas and the muscles would be weakened.[1]

More than two-thirds[2] of the entire mass of the brain is made up of fibres, and of these, by far the larger part are associational. These would be meaningless if discharges could not take place over them. Whenever a discharge takes place there is a transference of force. If one area could not assist another, we might expect its degeneration to follow the loss of its appropriate organ. This, however, does not occur except in case of a very young child. The blind do not have visual dreams if they become blind before five or six.[3] If associations become established with other areas, the visual seems to be retained. Donaldson thinks even the undeveloped cells in Laura Bridgman's brain must have taken some part in the general activity.[4]

Negatively : If each motor center must discharge separately, and there is a general tendency for nerve cells to build up continually beyond the point of equilibrium, then we must use each motor area regularly or it will discharge spontaneously, and thus continually disturb the process of thought. With the purpose of investigating whether or not such a tendency actually existed, a plaster cast was placed on the hand, so as to prevent any motion of the hand or fingers, and kept there for about 90 hours.

The evidence, so far as it goes, both in my case and that of another university student, on whom it was tried for 19 hours, is all in the negative. Very few motions were noticed and a reason could be found for nearly all of these. In my own case, on removing the cast, the pressure on the dynamometer was less than usual and the reaction time was three times as long 389 σ. The hand did not seem stiff after the first few contractions. This would seem to indicate that motor paths were becoming impermeable. Would this not indicate that the energy of the hand area had been used in some other way? We may suppose that here we have exactly the process by which an organ becomes rudimentary. It is not used for a long period, as the result its motor center is raised to a point of high tension. After a time the point is reached where it must overflow on other areas ; these paths become well established and this center is added to its neighboring centers, while old paths become impermeable from lack of use.

The cast served as a delicate register of minimal move-

[1] Mosso : Die Ermüdung.
[2] Donaldson : Growth of the Brain, p. 170.
[3] Jastrow : Visual dreams of the Blind, V. Princeton Rev., Jan., 1888. Donaldson : *Am. Jour. of Psy.*, Vol. IV, p. 291.
[4] Donaldson : *Am. Jour. of Psy.*, Vol. IV, p. 291.

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ments. The motor tendency of ideas was often quite manifest. Very often on reading the word contraction, or thinking of some motion, the tendency to move was recorded in a slight pressure against the cast.

In opposition to the facts heretofore cited, it must be said that, if it were strictly true that one activity could draw on all the brain energy, we could not tire our little finger until the finger muscle or the entire cerebrum were exhausted.

If the process of evolution has been from a homogeneous aggregate to a differentiated individual, we may expect that there was a time when each cell had to discharge separately and for its own ends. If the body ever becomes completely unified, we may expect the energy of each cell will be at the command of the body as a whole and can be used for *any* activity. The question is, where between these two extremes is man to-day; or rather, where is each individual man, for different men have doubtless stopped at very different stages on this journey, and the child has not gone as far as the man. The first connections we may suppose were among the different cells of the same area. The child is practically in this stage at birth. Nature has provided for the general education of the small child by requiring him to use each store of energy for its own proper activity. If he does not use each area, its energy accumulates and he becomes restless and even nervous. Rest for him consists absolutely in a change of work. With advancing age each area becomes more and more perfectly connected with other areas; but nerve paths like dry streams become choked up and offer a considerable resistance to the passage of the nerve impulse; as a result, the tension may be quite different in different areas, but the limit to this difference is the permeability of the nerve fibre. When this connection is once established, one area may exhaust another area to a certain extent, but never to its own level. If a person used to taking vigorous exercise suddenly stops, he will feel restless at first, but later will not mind it. This probably means that the connections between this area and others have been opened. In thus allowing one area to draw on another, nature has provided for specialization with advancing years. The more completely the brain is unified, the less will a man suffer from specialization. And on the other hand, perhaps, specialization and thus connecting all areas and interests with one area and interest is the only way to unify the brain.

It may be objected in opposition to these facts that localization becomes more definite as we go up the scale of life. It is true that each activity gains its cerebral station; but connections between the stations become more numerous. The doctrine of the partial unity of the brain force seems to me the

necessary neurological correlate of the psychological *fact* of association.

By permission of Dr. Lancaster I give a brief summary of his ergographic tests on "warming up." A weight of 700 grammes was used. Complete exhaustion soon resulted, so that the finger could not be moved. After a five minute intermission, in which the finger was contracted at intervals without the weight, a second curve was taken. Exhaustion usually resulted within a quarter of a revolution[1] in the first curve; but the second might be carried several times around the drum, and the weight could be increased from 700 to 1,000 grammes. Mental work served also to bring on this second curve. After exhaustion was reached in the first curve the muscle still responded as readily as ever to electrical stimulation of the nerve. This would seem to show that the fatigue must be in the nerve cells. How shall we account for this sudden recuperation with great gain of power? Dr. Lancaster's explanation is, that in the first curve only the motor areas of the finger are used, while in the second, neighboring areas have been drafted in. There is a "warming up" or second breath[2] for every activity, and in this second period there is usually a great increase of power.

If we accept Wundt's dictum that nerve cells tend constantly to discharge from points of higher to points of lower tension, we would have a simple explanation of this. Any used area becoming exhausted would cause currents toward it from adjacent areas, and a consequent establishment of paths connecting it with other areas. To use a simple analogy we have a chain of reservoirs with obscure connections between them, in all of which the water stands at nearly the same height. If now one of these reservoirs is drawn off, the water pressure will re-establish the connections, and the water will flow from the various reservoirs until it again stands at nearly the same height in all. The height will not be exactly the same because it will require a certain amount of pressure to force the water through the obstructions. Suppose now the attempt is made to drain off the first reservoir again, the connections with the others are established, and it can be drained only by draining the whole system. Thus, if any area is in constant use its connections with other areas will be kept open, and its endurance will be very great, while an area which is but little used cannot draw on other areas easily, and will be soon exhausted. In terms of mind this would mean we can attend for a long

[1] Contractions every one or two seconds.

[2] Partridge: "Second Breath," *Ped. Sem.*, Vol. III, p. 372. See also Lombard, "Muscular Contraction," *Am. Jour. of Psy.*, Vol. III, p. 27.

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time to a subject on which we have worked much and intensely, and only a short time to a new subject. This would seem to offer an explanation in neurological terms of specialization. One part of the brain, being worked constantly, draws on all the other areas until, we may suppose, in a well organized brain all the areas become associated with this one and discharge upon it, which thus uses the energy of the whole. It is the purpose of education to establish as many of these connections as possible, to unify the brain. If Wundt's principle is true, then we might expect the gravity toward any area to be in proportion to the completeness of its exhaustion: in other words, the way to master any subject and unify the the brain is by intense effort, for by this means other areas will be drafted in, associations will be formed with other interests and other knowledge.

In consideration of the facts heretofore stated, what should be the attitude of the student toward exercise? Is not the lean, hollow-chested student of the middle ages with his hatred of physical exertion the ideal to which we must return? Far from it. While severe physical exercise detracts for the time being from mental ability; in developing the motor areas, it ultimately places a larger store of energy at the command of the brain. As it seems to me the energy for any brain activity is mainly drawn from these motor areas. You find men of great mental ability who are physically weak, but you will not find many men of great mental *endurance*[1] who are so. I believe that, that energy which will carry a man through long hours of severe mental toil, which endures alike griefs and excitements and worries, is seldom found without a good physique.

The bearing of these facts on education seems to me plain. In the child the different areas are very poorly connected, hence we cannot use all through one, we must use each activity, and develop every interest, that we may have a larger store of energy for the brain to use later. Let all of the senses be trained, let each motor area be employed. In adult life let a man specialize and unify his brain so he can use all these stores of energy for any purpose.

PRECEPTS.

Give the mind over as completely as possible to one idea, lest of several ideas one inhibit the other and your energy be wasted.

A new worry or a new fear will drive out an old one. Two

[1] Sargent: North Am. Rev., May, 1897, p. 562; McLean, Phy. Education.

are not as strong as one. If one gets too strong find it a companion.

There is great danger that the intellect will crush out the emotions. Every worthy activity of the soul should have some period of time wholly to itself. Vices may be starved out by giving their store of energy to other activities. Put a harmless pleasure in place of an evil one, but do not take one away and put nothing in its place. "Nature abhors a vacuum." Put athletics and adventure in place of sexual indulgence.

The country youth has fewer temptations than the city youth, but he has also fewer things to divert his attention from those he does have. A new game, a new toy, a new hate, a new love, a new friend, a new enemy, will each abolish or lessen the importance of the old one.

The most exciting novel has its uses. When we find ideas pressing upon us, which we would not entertain, but cannot set aside, this is the easiest way to get rid of them.

Do not bother about your wrongs! Find something else equally as interesting to think about!

Summary.

The amount of energy which can be developed by any organism is limited. Up to a certain point exercise causes a muscle to increase in strength, beyond this it is weakened. But this point is only reached when all available supplies are no longer sufficient to repair its waste. Long before this point is reached it begins to draw on the other activities. Active parts are fed at the expense of resting ones.

Excessive physical exercise may stunt growth, reduce the flesh and strength, impair the heart and lungs, and dwarf the intelligence, or impair its efficiency for the time being. Where great drains are made on the energy to maintain bodily heat, as in polar regions, maturity is attained later and intelligence is often deficient. By excessive brain work growth may be checked, weight reduced, muscular strength lessened, the heart beat slowed, and dyspepsia and a physical break down brought on.

One activity may inhibit another; 1. By poisoning the blood with its waste products; 2. By robbing the blood of its nourishment; 3. By consuming the resting parts; 4. By using its brain area.

The nerve cell is as important as the muscle to muscular strength. Different brain areas are connected by associational fibers. These must imply discharges from one to the other and hence a transference of energy. If one area could not assist another, its degeneration would follow the loss of its appropriate organ. This does not occur unless the loss comes very early in

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life. The hand can be kept inactive without the hand area's discharging spontaneously. The brain is on the way to unity not yet entirely reached, connections are very poor in the child. "Second breath," or "warming up," means the drafting in of other areas to assist the primary activity. Constant use tends to associate the area used with other areas. Intense effort tends to unify the brain. The brain owes most of its endurance of mental toil to its motor areas. Develop each area and interest in childhood and use the energy of all in a single activity in manhood

III.

Restlessness.

Restlessness is a phenomena easy to observe, but hard to explain. It is movement without any apparent cause or purpose, resulting seemingly from some inner physiological necessity. Children are very restless, a quality which is shared by the young of all animals as well. It is the root from which the play impulse springs, a surplus of energy requiring employment. As the young animal grows to maturity and requires all his energy to secure his living, play disappears. But, whenever food is provided and the struggle for existence is made easy, a surplus again accumulates and manifests itself in a vague uneasiness. Notice, for instance, the restlessness of caged animals, the runaway spirit of a horse that has been long in his stall, the effusive joy of a dog at the prospect of a hunt, and the wanderings of all our domestic animals. If the ends of life for an animal are food and shelter, we might suppose, that these being attained, no effort would be made. But this is not the case; an animal which is fed all it can eat and in considerable variety will still wander; though it seems as if this instinct were beginning to die out. I have watched the movements of fatting hogs for hours. An over fed hog will wander aimlessly about his lot, lying down every few rods, only to get up and wander on again. But an old hog is not nearly so restless as a small pig. Confinement and an easy life are reducing his natural activity. Birds are very restless, almost nervous in their movements. In watching sparrows in a tree before my window with a stop-watch in hand, I have often seen them turn their heads or make other movements up to the number of 60 or 70 times a minute.

But any one who observes children must very soon perceive that they differ greatly in activity, from their earliest years. In the hope of securing a more accurate measure of this, I secured four American pedometers and put them on adults and children of various ages, and asked some responsible person to

keep record of the day's activity every night for a week. The results were not as satisfactory as might have been hoped, as the pedometers were not very reliable and had to be regulated every week or two to keep them running together. The records given are not really accurate for miles, as the pedometers were all set to a 20 inch step, this of course would be too long for a small child[1] and too short for a man, being about an average step for a woman of medium height. This, however, shows the number of steps each person took in a day, or the real activity which was the thing desired. This means 2,754 steps for every mile represented in the record.

The following is of city children not in school.					Country children in school.				
	Sat.	Sun.	Mon.	Ave.		Sat.	Sun.	Mon.	Ave.
M. 6	11½	3¼	7¼	10⅜	M. 11	9½	3½	7½	7½
M. 2	9½	6⅞	9½	8 1/3	M. 13	10½	6½	10¼	9⅜
M. 1½	6⅝	6	7⅛	7½	M. 9	12½	6¾	8	9⅜
M. 4	7	8	13¼	12⅜	M. 16	8	3½	6	7⅜
M. 6	10¼	7½	14¾	10½	M. 11	11¾	7¾	7¾	10
M. 4	7	6	8	7⅜	M. 16				6
Ave.	8 9/16	6¼	10	9⅜	Ave.	10⅜	5⅜	7⅜	9½
City children in school.					Adults.				
F. 14	10½	8¼	6½	7¾	F. 34	13½	5½	6⅜	7⅞
M. 10	9¾	7½	5¼	6 1/4	F. 36	10	9½	9¼	9⅜
F. 6	11½	11⅜	8⅛	11	F. 60	14¾	4	17	10⅝
F. 12	11⅜	6⅜	11	8½	F. 32	10⅛	7	9⅝	7⅝
M. 15	10½	13	17¾	12⅜	M. 36	7⅛	4¼	6¼	6½
F. 17	6½	4	5¾	6	F. 34	5½	3½	8½	5⅞
F. 10	11	10¼	11	10¾	M. 26	15⅛	12	9	10½
F. 8	13½	5¼	8½	8	F. 21	11	3½	8	9⅜
F. 10	10½	7	7⅓	7¾	F. 26	5¾	5¼	6¾	6½
F. 10	12¾	8½	9½	9½	M. 28	2	3¼	2¾	2½
F. 13	14	10	13	13 5/6					
M. 15	4½	3⅛	7¾	5½					
Ave.	10½	7 11/12	8 1/12	8⅝	Ave.	9½	5¾	8⅜	7½

From these tables and curves it will be seen that the averages of children below the school age are largest; it would also appear that country children are more active than city children. But the activity of the country children from whom the records were obtained was considerably above the average, I think. The activity of the girls and boys, men and women, is nearly the same. The adults were engaged in various occupations; the lowest record is my own while teaching in a country school.

[1] The real distance travelled may not be so very different, as children run a great deal and take longer steps at such times.

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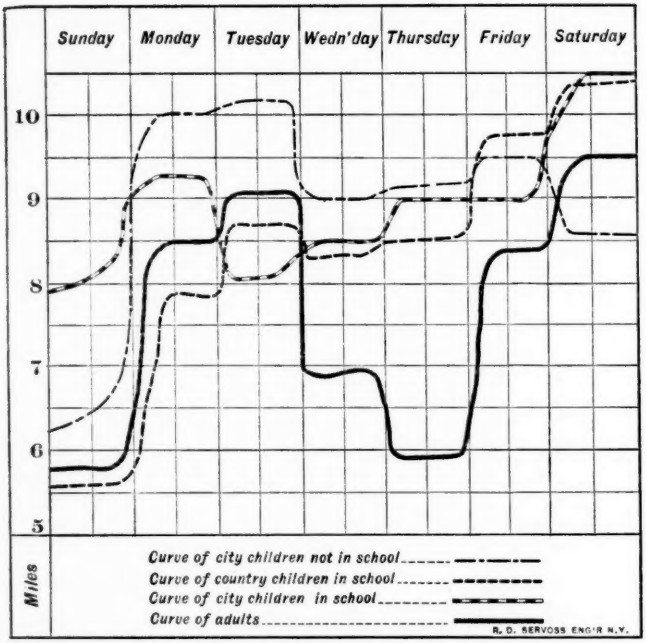

The activity is least on Sunday for all, and greatest on Saturday for all but the small children. Wednesday and Thursday[1] seem to be days of low activity also. But of course the numbers are too small to draw many conclusions.[2] A great many records had to be thrown away on account of some defect in keeping, some of these emphasized individual differences more than any preserved. Still a considerable difference will be seen from the table.

Sitting Still.

The syllabus brought in something over 200 returns, of which the larger part were from the New Jersey State Normal School. The first purpose of the syllabus was to determine, if possible, whether the restlessness of children is a real physiological necessity, as is so often stated, or that it is merely the result of inclination.

[1] It will be seen that the results for the different days are not averages of large and small. The individual curve varies but very little from the average. The curves were made from the original records, not from the table.

[2] I hope to carry this experiment further.

The first question was as follows:

I. Ask your child, or, if you are a teacher, ask a few children at a time in your room, to take some easy position and see how long they can sit still without any movement, meanwhile with watch or clock in sight note time, and put down (a) which part moves first, fingers, feet, head, arms, legs, etc., (b) what kind of motion, usual or unusual, violent, or gentle.

(c) What efforts do you see to prevent these spontaneous movements, as, *e. g.*, tension of all the muscles, clenching mouth, hands, etc.?

I give some of the most characteristic returns.

M., 6. Fixed his eyes on one point, but he could not remain still; he would fold and unfold his hands, cross his feet and move his whole body.

M., 9. Sat still one minute, I then noticed a twitch of the lips, then a movement of the lips. He finally began to move all over and then got up.

I asked M., 6, to sit perfectly quiet. At first he said: "I can't," but finally sat down and remained quiet about 50 seconds.

F., 6. Sat still three minutes. She moved her head first. She clenched her hands in her effort to keep still.

F., 8. Looked at a point one minute, then her fingers twisted, and she said she was tired.

F., 6. Sat still 30 seconds, when she moved her hand, apparently without knowing it.

F., 4. Sat still 40 seconds, then moved her foot. When I told her she had moved her foot, she looked at it and said, "O! I could n't help it."

F., 8. Sat still 50 seconds, then crossed her feet.

M., 5. Did not remain motionless for a moment, his hands moved first, then his feet.

F., 9. Sat motionless three minutes.

M., 9. Sat still for one minute, moved his foot first.

F., 9. Sat perfectly still for thirteen minutes.

F., 4. Did not sit without movement for more than a minute.

Of course all these returns are very much abbreviated, but altogether they contain the most characteristic features. From the nature of the returns it would be difficult to make a table of just how long each child sat without moving. The differences are very great; but my own tests and the tests in the returns (so far as the exact time is given) will, I think, justify the statement, that children under five will not, as a rule, sit still more than 30 seconds, though now and then one will sit still as long as ten minutes. Children under ten will not usually sit still more than 1½ minutes, and oftentimes less than half a minute, though one or two have sat as long as 20 minutes. These results seem to show that the average child *cannot* sit still in a *test* for more than a very short time. But do they prove that a child cannot sit still? It is hard to tell because the test brings in several unusual factors.

Probably one reason children do not sit still longer in a test

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is because they make so great an effort to sit still. They usually clinch their hands, contract their brows, and set their teeth; as though they were going to lift a thousand pounds, instead of merely do nothing. Their breathing is often irregular, and they frequently try to hold their breath. They have the consciousness of being watched also. A little German girl of five said to the one who was observing her, "Don't look me all the time on." So, too, thinking about movements even negatively, always tends to cause them.

All these circumstances tend to make sitting still more difficult, but their influence is probably less than we might suppose at first. There are many children who do not make a great effort to sit still, but they do not succeed much better than the others. In the clinching of the hands and setting of the teeth also, you have an expression of the child's judgment, that sitting still is a hard thing to do. Doubtless there is a suggestion in the test that may have something to do with this. But a child will often say he "can't," when you ask him, and says he is "tired" afterward. In speaking with adults I find that some of them still remember, with a feeling of pain, the times they were required to sit still as children.

I think that, all things considered, the evidence will justify the conclusion, that the ordinary child cannot sit still *voluntarily*. It remains then to explain this restlessness and the cause of its disappearance, if we can.

Motion is one of the most universal characteristics of the animal world: to produce motion was the primal purpose of all nerve cells and nerve centers. Muscles might contract on contact, but it was necessary for the good of the organism that not merely one muscle, but a group of muscles should contract to secure or avoid not only contiguous objects, but objects often at a distance. It was thus necessary, that some slight stimulus, acting from a distance on some sensitive part, should liberate a large store of energy. At first there are simple definite reactions to each stimulus. But, as the environment increases in complexity, more and more complicated reactions are demanded, and intermediate cells are developed connecting the different reflexes. These cells increase in numbers until ultimately all reactions are joined with all stimuli, and the associational or rational levels of the cortex are developed. In the first state, the stimulus passes from the sensory cell to the motor cell, and brings on a reaction. But now the stimulus may be consumed in maintaining the activity or nourishment of a long series of cells, or stimuli may clash with each other, so that no action may follow for the time. This associational or intermediate area, receiving the stimuli from all sources, is always active in the working state. It thus not only serves as

a complicated switchboard for the nerve currents, so that each activity becomes more or less independent of its own stimuli; but very likely, it serves as a storehouse of stimuli as well, so that *all* activities gain a partial independence of present stimuli. Here is born the possibility of rational control. In the fusion of its various sensations reason arises. But all that the higher areas have gained has been lost by the motor areas.

As the associational or rational areas were the last to develop in the race, so these are the last the child comes to use. In the meanwhile stimuli are transferred by earlier paths upon the motor areas, and these suffer from an excess of stimulation. When you add to this the fact that the poorer connection of the parts of the child's brain requires that each activity use its own store of energy; we have, what seems to me at least, the real explanation of the child's restlessness. In accordance with this principle we may expect restlessness to diminish with the increase of intellectual activity.

In psychological terms this means, that thought or attention and restlessness are in inverse ratio. Observe an audience when interested and when not! In striving for a state of attention or in expression of it automatisms are often increased. But when it gains possession of us, motion decreases with the increase of our concentration.[1] It is the same with the child. *He can sit still as long as he can be interested.* Even a very small child will sometimes sit like a statue for a considerable period, when his attention is taken by some bright or otherwise interesting object. A child's interest is shorter lived than a man's, because he has fewer associations with objects. He has but little power of abstract thought, and his interests are largely motor. I think each explanation is translatable into the terms of the other.

It should be mentioned further that intense attention tends to stop even the organic rhythms. The eyes are held open, respiration ceases, and even the heart may be checked for a moment.

In observations and tests upon the blind children at the Perkins Institute and Jamaica Plains, I found them much more restless than normal children.

Many of them kept their eyeballs rolling constantly.[2] A trait said to be common among albinos also.

In five-minute tests upon ten university students very few motions were noticed, and restraint was oppressive only in two cases. The eyes and lids were the most restless members.

[1] Ribot: Psychology of Attention, pp. 11 and 49; Diseases of the Will, p. 34.

[2] Laura Bridgman did the same, *Am. Jour. of Psy.*, Vol. IV. p. 281.

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There seemed to be two winking rhythms, one slight and very rapid, the other a decided twitch, which would have been a wink had the eyes been open. The winking rhythm, according to my observations, made with a stop-watch during lectures and addresses, varies from 5 to 45 times a minute, with 20 as the average rate. It varies with mental conditions, and is inhibited by attention. It might prove another psychic index if it could be carefully studied. In close attention the lids may be held for nearly a minute, when seven or eight winks usually follow each other in rapid succession. This movement is so rapid[1] that the image is continuous, and we are usually quite unconscious of it.

Slight twitches of the fingers and turns of the head were the only other movements.

The answers received in reply to the syllabus show a much greater restlessness.

Syllabus, question XIV. Will you compose yourself in a comfortable position sitting, lying, and standing, and remain as still as if you were having a slow photograph, and describe your experience freely?

F., 18. At the end of four minutes I could not sit still for another minute.
F., 18. My muscles seemed tense, and I soon became tired.
F., 18. I did not experience any very unusual sensations.
F., 17. I felt as though it were a great strain on my muscles.
F., 18. It seemed as though I simply could not keep still.
F., 18. I could sit still 15 seconds.
F., 17. At the end of the third minute I felt as though I could stand it no longer.
F., 16. My feeling was one of rest.
F., 17. I heard every sound about the place.

It will be seen that the results are very different from those obtained from the university students, but the conditions were also very different. I have no difficulty, and feel no discomfort in *sitting still* for half an hour while thinking. But I find it very uncomfortable to sit still for five minutes and observe my sensations.

Sensibility is much increased. Many sensations, which normally remain below the threshold of consciousness, are raised into distinctness, and it is the little itching, pricking, rheumatic sensations, which soon make sitting still disagreeable if any one allows himself to notice them. So also the motor tendencies of all sensations become apparent. Infinitesimal impulses to move are magnified into strong desires by the attention they receive. A man is thrown back upon the old sensori motor mechanism by which motion is produced. The

[1] Mayhew found the average time to be 42 σ in 450 experiments, Jour. of Ex. Med., Vol. II, p. 47.

evidence of these facts, so far as it goes, seems to substantiate our previous conclusions.

I think it is both true, that the child is restless because he is inattentive, and inattentive because he is restless. But the latter is primary.

Restlessness in Sleep.

Syllabus, question IV. If you have an opportunity to observe children or adults in sleep, notice if they are ever perfectly still for any considerable period, or do their eyelids or lips move, expression of the face change, fingers clinch, etc.

I quote from the returns :

The longest time M., 23 months old, was perfectly quiet was 55 seconds. He went to sleep with his thumb in his mouth and every few seconds he would suck it vigorously.

F., 3. The eyelids are almost always in motion, the fingers move, the arms are raised, the head moves slightly, the mouth opens and then shuts, the legs are drawn up every now and then.

M., 10. Was perfectly still for ten minutes except that his fingers would twitch every little while.

I observed M., 10, for about an hour, and during that time there was scarcely a minute in which he did not move slightly.

F., 5. Will roll over usually and sigh and is apt to awaken, when people watch her.

F., 2. Moves her hands, draws up her limbs, puts her thumb in her mouth, twists her mouth, gapes, moves her eyelids.

Out of 97 observations on children and adults under this head, 83 report movements and 14 report none. Most of the observations were not for more than ten minutes, and a larger number might have proved restless on longer observation. The children I have observed were seldom quiet for half a minute at a time. In wearing a pedometer of special construction every night for a week, this recorded from 60–127 each night, with an average of 75, although nothing but turns of the entire body were measured. With another university student, who wore it three nights, the average was 86.

Descartes might have taken these facts as proof of his principle that, "the mind always thinks;" still they probably are pure reflexes. Sleep is a sort of reversion, a falling back upon lower levels of development, and as a consequence the excitations follow earlier paths and the associational areas are little used. The higher levels drop out and inhibitions with them. Dreams are mostly in sensor-motor terms. Slight stimuli probably would not arouse a general consciousness.

The Restless Child.

Syllabus, question V. Describe one of the most restless children you know, complexion, health, stature, flesh, color of

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eyes, hair, etc., bright or dull, good or bad natured, regimen, discipline, etc., associations gay or sad.

I quote from the returns :

F., 6. I have never seen this little girl sit down to one thing for more than 15 minutes at a time. When she is asleep, she kicks the bed clothes and tosses around.

F., 6. Is very fond of playing with other children, but is so rough she cannot be trusted to play with a child younger than herself. She is unusually large and strong, quite fleshy, and very dull.

M., 4. When he is awake he is never still a minute. For a punishment he is often told to sit in a chair such a length of time. But even then he is not still ; he twists around, moves his legs and arms, plays with his fingers, etc.

F., 10. Has lately become very fond of reading, so she is not so restless.

F., 5. Seems to be very thoughtless and will hurt some of her playmates, but is then very sorry and will cry.

M., 8. Is constantly moving about in school and it seems impossible to hold his attention.

M., 5. Is always out in the street playing with every child that will play with him. He is into all mischief imaginable. He is never still for five minutes at a time, even while eating.

M., 7. Is very restless, delights in teasing and sports of an acrobatic nature.

F., 7. Is very severely punished when she does not obey, but she never minds this and will do the same thing again and again.

I have sought to select cases which give the most common characteristics. The number of cases was 152. The significant characteristics seem to be as follows : Good health, 93 ; poor health, 25 ; bright 123—of these, very bright, 71 ; dull, 10 ; tall, 41. These characteristics came out in answering the questions of the syllabus. The following, also, came out prominently, though only incidentally mentioned. They are apt to be boisterous and rude in their play, and often hurt other children without intending to. They are mischievous and disobedient to parental authority. They are often whipped but do not mind the whipping. They seem very insensitive to pain. The majority of the restless children described are under six years old Restlessness appears to disappear with mental occupations.

The restless child seems to me an especially instructive type and one that is very little understood. He is the child who makes most of the trouble for his parents and the teacher. He is often thought to be willful and bad, and may be made so, if he does not receive proper training.

Restlessness as applied to children below the school age may be taken as nearly equivalent to activity. The physical activity of a child at this age is a very fair measure of the energy he develops. If this be true, then nothing is more evident than that different children come into the world with very different amounts of energy ; or better, with the capacity

of producing very different amounts of energy. Just as one animal will grow fat on a quantity of food on which another would remain lean, owing to the more excellent nutritive powers of the first, so the nerve cells of one individual may be built up more rapidly than those of another, and a larger amount of energy set free. For, if our word energy is equal to nerve force, then it seems fairly evident that the amount of energy of an organism must depend on the number and rapidity of metabolism of its nerve cells. But on the latter very much more than the former. If the metabolism is rapid, then the nerve cells are kept at high irritability all the time and the individual is restless and must act. This is at least a part of the constitution of the energetic, ambitious man in all departments of life. But on the other hand, if the rate of metabolism is slow, nerve cells will remain poorly nourished and unexcitable, there will be little spontaneity in childhood or later, as a strong stimulus is necessary to discharge one of these nerve cells. The person is "born tired."

The restless child is, as a rule, a peculiarly good animal, as well as seen from the characteristics given, boisterous, rude, mischievous, disobedient, talkative, insensitive to pain, fond of teasing, often cruel, destructive, social, often leaders, bright, yet thoughtless.

Restlessness in children up to six or seven years of age seems to be a good sign, but a bad sign afterwards. It does not usually last much later than this in its extreme form. The restless child should naturally develop into a man of action.

The Quiet Child.

Syllabus, question VI. Describe in the same way one of the most quiet, inert children you know. Are they lazy, self-conscious, companionable, do they associate with older children, are they studious, thoughtful, sad, or gay, etc.?

I quote from the returns:

F., 12. Is the quietest child I have ever known. She is far from being lazy, for she is always working hard over some little contrivance she has made, or some new way to fix a toy.

F., 9. Very rarely associates or plays with other children, but would rather stay in the house and study or play by herself.

F., 7. Is studious, she will sit for hours reading without speaking aloud.

F., 12. Attended my school and attracted my attention by her quiet ways, sometimes never leaving her seat at recess or noon. She seldom ever played with the other children. I looked upon her as an angel child.

F., 7. Has that modest expression to her face like a grown-up person. She does not play out in the yard with other children, but prefers to stay in the house with her grandmother, with whom she lives.

M., 8. Says very little, and would rather sit down and do nothing than play.

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F., 6. Is one of the most quiet children that I know. Her movements are gentle and slow, and her voice is low and sweet. She seldom speaks or plays with other children, but is quite content to stay in the house and play with her dolls all day by herself. She is always moving about doing something in her own quiet way.

F., 5. Never plays with other children. If spoken to her face flushes instantly, her hands clasp and unclasp, while she will not speak above a whisper.

M., 6. Would sit all the time at school, except recess and when called to recite, and watch the door, 10 feet away, and not move, as I could see, hands together, arms on desk.

Many observers said they did not know any quiet children. Their characteristics as compared with the restless children are as follows:

	Quiet Child.	Restless.
No. of cases	108	152
Good health (mentioned)	44	93
Poor health	22	25
Bright (all)	57	123
Very bright	14	71
Self-conscious	28	
Thoughtful	45	
Studious	27	

It would appear that the health of the quiet children is not as good, and they are not as bright as the restless children. But of course the numbers are too small for safe conclusions.

Several types of quiet children can be made out.

1. There is the child who seems to lack energy all around, he is inactive mentally and physically, he is the typical dull scholar at school, he cannot be educated without unusual stimulation.

2. There is the child who is inactive from sheer rapidity of growth. He grows five or six inches in a year, and lies around all day.

3. Fat children are nearly always inactive.

4. The large number who are said to have poor health would indicate that loss of energy, due to disease, is one very important factor.

5. Overwork, mental or physical, is sure to produce quietness.

6. Many quiet children are only children.

7. There is a quietness in children which is a sort of precocity; they are premature adults. They have an abundance of energy, and are bright and studious—the parent's ideal of what a child should be. Many great scholars have been of this type. Quiet children are usually timid, bashful, sensitive, both to pain and slights, self-conscious and thoughtful. They must be handled with velvet gloves; a gentle reproof is

often a more severe punishment to one of these sensitive natures than a severe whipping to one of the rollicking, restless children.

Conditions of Restlessness.

In answer to the question: When are children most restless? there were 148 replies.

F., 17. I have noticed that children, who are not restless at all on clear days, are sometimes very restless on cloudy days.

F., 24. On cloudy or stormy days the restlessness was remarkable, and even exercise failed to quiet them.

M., 27. Children are most restless on days preceding a storm, so that an old teacher can tell the weather by the action of the pupils.

F., 17. Plenty of vigorous outdoor exercise makes a person less restless at the time, but if stopped suddenly they are more restless.

Out of the 148 returns, 2 said children were most restless in the morning, 112 in the evening, 14 on bright days, 107 on cloudy days, 8 in the fall, 110 in the spring; 15 said exercise increased restlessness, 116 said exercise decreased restlessness.

That children, as well as adults, are most restless in spring agrees with general observation. Perhaps there is a trace here of the primitive home-building and migratory instinct. Children certainly are more restless, if kept from active exercise, and on bad days, these two cases are often one, but not always. Several teachers from different parts of the country have said that children are more restless on days *preceding* a storm. Many of the lower animals seem to possess a barometric sense. Havelock Ellis[1] says this is stronger in women and children than in men.

When the class becomes restless the teacher may take it as a sign that the work or method should be changed.

The conditions of restlessness seem to be about the same in adults as in children.

F., 17. After an active life in vacation, it takes me a week or so before I can settle down and accomplish anything at my school work.

F., 21. When I change from an active to a sedentary life, I get sleepy early in the evening, and do not care to walk or study. I have often noticed this.

F., 18. I am not as lively and cheerful, as when I take plenty of exercise.

F., 32. The tendency to restlessness was very great in changing to a sedentary life. After studying a while I would feel compelled to jump up and pace rapidly across the room for several moments. I had frequent nervous headaches, my digestion was somewhat impaired, and I could not sleep well. It wore off in a month.

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[1] Man and Woman, p. 274.

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Going Without Customary Exercise.

F., 19. If I go without my usual exercise, I become very cross and disagreeable.

M., 30. I become restless, nervous, and have headache.

F., 23. It causes restlessness, irritability, blues and impulsive movements.

F., 18. I get sleepy much earlier at night, and cannot rest as well.

F., 18. I yawn and feel tired and lazy. I have headache and see everything on the dark side.

A short time ago I heard the president of one of our largest normal schools say, that when school was out and the pressure of his work ceased, it seemed as though he would go crazy for a week or so until he got adjusted to new conditions. He thought this the cause of the death of Napoleon at St. Helena.

There were 114 cases: restless, 75; gloomy, 11; fatigue, 7.

Going without exercise, 123 cases: nervous, 13; stupid, 20; headache, 10; stretch, 47; irritable, 17; yawn, 67; gloomy, 6; restless, 66; sleepy, 18; impulsive movements, 51.

In the case of a change from an active to a sedentary life, the resulting restlessness would seem to indicate a certain accumulation of energy for motor uses, which is either used for other purposes later, or the rate of metabolism of motor areas slows up to a slower expenditure. In case of going without regular exercise the case is apt to be complicated with overwork and the disturbing of rhythms.

Sickness.

There are several interesting things to be noted in the case of people who are not well.

F., 18. In a slight indisposition I am very restless. I will sit or lie in one position, and then in a few minutes will move again. Every little thing annoys me.

F., 39. When my mother has a headache or nervous attack her hearing is more acute than at other times. She can hear every word of a conversation going on on another floor.

M., 19. When I am slightly ill I am very easily distracted, and become nervous over every little noise. I had typhoid fever once for 16 weeks. Even a fly walking on my face would make my flesh creep all over.

F., 17. My cousin who has been in bed for three or four years at a time, and is now 18, is entirely changed from a child. When she was first taken sick at five years old, she suffered more because she could not go out than from pain. When she was able to go out after four years she was very quiet.

F., 19. After a long illness one becomes very sensitive to changes in the temperature and tactile sensations.

F., 18. When I have a slight sickness I feel cross toward everybody, and it seems as if everybody goes against me.

F., ——. I have noticed that I am very cross when slightly ill. It makes my tactual sensations keener.

The numbers here are too small to have any statistical value, and can only be used as illustrations of facts already known.

The restlessness of the sick requires no further explanation than a consideration of their inactivity, discomfort, and the keenness of sensation. The keenness of sensation is mainly due, probably, to the attention it receives. The sick man has little else to attend to. But in other cases it can only be explained as due to the irritability of the area involved, caused in some way by the disease. Increase of hearing power is often mentioned in the returns. One often hears it mentioned by sick people. Perhaps this is one reason that noises annoy the sick so much.

Sickness is a delicate scale in which we may weigh the receipts and expenditures of life. Every energy of life seems to concentrate to resist the disease, and all other activities fall out. The sick man's resistance to stimuli is diminished, and we see more nearly what the influence of each element in the environment or each subjective effort is. Even the effort of sitting up or conversing is plainly registered in this delicate scale. Noises irritate us.

If we follow development backward it would appear that the first purpose of every stimulus, from whatever sense, was to produce motion. Secondarily all these sensations serve as the basis for the development of intelligence. But the fact that every sense stimulus still serves to increase the pressure on the dynamometer, shows that their motor tendency is not yet lost. If stimulation tends to make nerve cells irritable unless they react to it, then every sense stimulus will *tend* to produce nervousness and restlessness. There must be a degree of stimulation, which is best for each brain, which will be in inverse ratio to its excitability.

Let us examine the auditory stimulus for a moment. It is continuous during our waking state and to some extent during sleep also. We do not consciously, but may, if we will, hear a great variety of noises at any moment. Noises make sick people nervous and restless, cause nervous headaches, increase muscular power[1] and tend to cause motions (as any one can observe in sleeping children). These sounds are more or less suppressed in proportion to the mental concentration at the time.

These facts give further evidence for the theory heretofore advanced. We say the brain is always active in the waking state, but by this we do not mean its motor areas nor consciously its sensory areas, but rather its higher areas, active in deliberation. That brain cells are active in thought is shown by the increased rush of blood to the head,[2] its raised temper-

[1] See part II.

[2] Mosso Die Ermüdung, p. 70, seq. Sanford, Dawson, Exper. at Clark University (unpublished).

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ature, and the excreta thrown into the blood.[1] We must assume a constant stimulation to maintain this constant activity.[2] This can only come from sensory nerves; yet the areas stimulated are not sensory areas, nor does stimulation result in sensation. The intense activity of higher levels inhibits sensation.[3] Must this not mean that the stimuli of the sensory areas are used to maintain the activity of the higher areas? If nerve cells tend to discharge from points of higher to points of lower tension, then any active area would tend to cause discharges upon it from all areas connected with it. The strength of this tendency would be in proportion to the intensity of the action of the active area. If, on the other hand, a considerable sensory area were aroused, it would cause a discharge from higher levels, which would increase sensation and divert the attention. If two areas were active at once, the current would shoot across and the two would be associated.

Returning to the special sense of hearing, we may suppose that this constant din of incoming noises is one of the chief means of carrying on the activity of the brain. Donaldson mentions a case of a boy who was bereft of all his senses except hearing in one ear. He says the boy would go to sleep immediately, if this ear were stopped with batting.[4] Sharks will not move or feed, if their olfactory sensations are cut off. Probably we are more dependent on visual and auditory stimuli than any others. The numerous stimuli of city life cause the nervous system to develop more rapidly than it does in the country. Puberty comes about two years earlier. They enable the average man to maintain a much more intense effort than he would be able to do in the country. Probably the noises of the city are a benefit to phlegmatic people in helping to keep up their nerve force. But to many intellectual workers they are excessive,[5] and to the nervous and the sick they are misery.

It may be asked "Why are sounds so much more insistent than sights?" The ticking of the watch on my table annoys me more than the whole row of books, the scratching of the pen more than the sight of the pen and the moving hand. The sound stimulus seems to be more powerful and the reason may very well be, that sounds are not as continuous and are more important individually than sights; inasmuch as sounds always indicate that there is something moving or doing something, and were consequently of great importance to the organ-

[1] Binet and Henri: La Fatigue Intellectuelle, p. 332.
[2] Donaldson: Growth of the Brain, p. 284 and 285.
[3] Ribot: Psychology of Attention, p. 95.
[4] Growth of the Brain.
[5] Kant, Schopenhaur, Rousseau, Carlyle, for instance.

ism in seeking its prey and avoiding its enemies; while the great majority of the visual field has no interest whatever to the animal. Some one should study the dynamogenic value of different sense stimuli, as correlated with the past of the race. If one odor liberates a certain amount of energy, and another odor a very different amount, the reason for this probably lies in their associations with dangers or effort of some kind in the distant past.

How shall we explain the hunger for noise of small children? Very much the same as any other hunger, I presume. The auditory cortex craves stimulation, and the small child with his rattle is laboring in one of the first stages of his education —sound discrimination.

If we must look to external stimulation for the ultimate source of all motion, we must see in noises one of the main causes of restlessness.

Sight furnishes a perfectly continuous stream of stimuli during waking hours, but the visual cortex is better connected with the higher levels than the auditory and its motor expression is consequently better inhibited.

EXCITEMENT.

Excitement is pre-eminently a restless state, and is perhaps the state in adults which most resembles childhood.

F., 31. Excitement makes me talk more and faster than I usually do.

F., 23. In great excitement I cannot control my actions or do anything requiring movements of the small muscles. I am unable to sleep. If the excitement is very great, I am almost paralyzed mentally and physically.

F., 18. Excitement, if long continued, makes me tired and usually ends in a sick headache.

F., 17. Excitement makes my hands cold.

F., 20. The effect of excitement is to make my cheeks hot and red, my head seems to feel clearer and I talk much more glibly; yet the play of my fingers on any object shows nervousness and afterward I feel tired.

F., 17. I want to fool with something when excited, and usually bite my finger nails.

F., I enjoy excitement because it relieves me of my cares for the time being.

F., 24. Excitement makes me ill for a short time. I am usually confined to my bed and have a nervous headache.

F., 18. I lose all control of my thoughts, and think of everything but the right thing.

The physical effects seem to be a violent beating of the heart, flushing of the face, increased circulation in the brain and great irritability of all cerebral cells, which results in a diffuse discharge upon all the muscles and glands, causing tremors, nausea, and various similar phenomena. The individual is very restless and often nervous. The cerebral ex-

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citement is too general to be inhibited; it is like a city all on fire at once, with which the engines can do nothing. Every stimulation tends to issue in an immediate reflex. The philosophic powers drop out. A person is thoughtless and impulsive, he tends to speak all his thoughts, is apt to be irritable and takes offence at the slightest cause, he loses control of his muscles, his hand trembles, it becomes absolutely impossible to sit still, all automatisms become very pronounced, he is unable to sleep at night. The symptoms of excitement and a mild state of intoxication are very much the same, both are pre-eminently social and motor states.

Perhaps excitement is good for most of us occasionally. It makes us forget our cares and serves as a sort of Turkish bath to the nervous system, to open all its pores and make all its paths permeable.

The characteristics of childhood resemble those of a constant state of excitement.

Summary.

The activity of children below six, as shown by pedometer records, is greater than at any later period. But children differ greatly in activity.

Children under five could not sit still longer than 30 seconds in the test. Children under ten could not sit longer than one and a half minutes.

The rational cortex, probably, arises as a series of intermediate cells for connecting the various sensory and motor areas. This rational or associational area at length becomes so great that a large part of the stimuli may be consumed in maintaining the metabolism or activity of its cells. All that the rational areas gain is lost by the motor areas, as the first purpose of every stimulus was the production of motion. The rational or associational areas are the last to develop in the race and in the child. With their development restlessness is inhibited in a degree proportional to their activity. They inhibit lower areas by using their stimuli. The child can sit still as long as he can attend.

Blind children are more restless than other children.

The nerve cells of different individuals seem to have different rates of metabolism, and as a consequence one may develop much more energy than another.

Children are most restless near the close of school, on cloudy days, in the spring, when they go without exercise.

Auditory stimuli are perhaps of great assistance in maintaining the activity of the brain. Hearing is inhibited by thought.

Excitement and restlessness are closely allied.

IV.

Pedagogical Inferences.

From what has been said we see on the one hand a great danger, excessive brain work, and on the other a great need, physical exercise. Can any system be devised that will obviate the one and satisfy the other, and at the same time secure equivalent mental results.

Coming up from untold generations the progenitors of man have been successful in adaptation to environment, in finding food in time of scarcity, in securing prey or escaping their enemies very much in proportion to their activity. Movement is the most basal thing in the animal world. The "joy of movement" is one of its most deep seated pleasures. No one can notice lambs or colts or any young animal without feeling this. The child is still in the animal stage of his existence. The irresistible impulse, which has come down from that struggle in ages, when life and food depended on fleetness of foot and strength of endurance, is still surging within him, and drives him on to action. Not only does he refuse to sit still for a half a minute at a time, but he seldom walks when going anywhere, but runs or gambols along like a young animal. A very large part of all his games are running games. Of the children I have questioned as to whether they liked to go to school or not, nearly every one who has said "no," has given as the reason, "because he had to sit still," or "stay indoors," or some other reason which meant restraint of motion.

A boy of seven once said to me of his own accord: "Teacher, I don't like to sit in these old seats so long. After I sit a while it seems as though I'd just have to get up and run around the schoolhouse." He was rather of a quiet boy, too. Children will contend for the privilege of collecting the waste paper, or distributing the pencils, etc., where they would count it work at other times. A housed and seated child is like a caged animal, all his most fundamental interests are put in abeyance.

If childhood is the animal period of life, it should be the time for animal (physical) culture. It is then that interest in and love for physical movement is greatest. The greatness of childhood consists in swiftness of foot and strength of body and limb. The school hero is usually the boy who possesses these qualities.

Childhood is the time of the greatest spontaneity of motor centers. If the strength of the contraction of a muscle is determined by the strength of its stimulation, is it not probable that its increase in strength will be determined by the amount of its stimulation? In other words it will be most rapid in

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youth. If motor areas furnish a large part of the energy by which intellectual labors and worries are to be borne, it is exceedingly important that these be developed to their utmost as early as possible; that a broad basis of health and endurance may be raised on which to build the superstructure of higher things. Physical health and development must be the first interest of education. Public gymnasia should be established, and every city should furnish ample playgrounds or athletic fields. The Spartans put their youth under training at the age of seven.

On the other hand we must consider for a moment what is the effect of our present system, so contrary to nature, upon the child. We have seen that excessive brain work may dwarf the stature and weaken the constitution. We know, also, that from 15 to 60 per cent. of our children become nearsighted before leaving our schools; that a very large proportion, especially of the girls, have curvature of the spine; that a great many become nervous, and not a few have chorea; that among the girls at least only a very small proportion finish the high school in a state of good physical health. Not all of these evils are due to the school, but at least a part are; to that part for which the school is responsible there are two elements: the one to overwork and worry, and the other due to being indoors and enforced inactivity. We have seen how difficult it is for the child to sit still; that it is this which makes school disagreeable to him; that his personal discomfort makes it hard for him to keep his mind on his task; that long restraint tends to make him nervous. However, it seems probable that the lesson of quietness is one which it is necessary for the child to learn. There is no probability of his acquiring the power of deliberation until he has learned to be still. We have conjectured also that the high pressure of motor areas may be instrumental in making their associated connections permeable. Hence we cannot agree with Dr. Shaw that the ultimate solution of this problem is "using the motor activities in teaching," though that is perhaps the only solution, if we are to require so many hours of school. But does it not seem absurd to require of the child so much confinement? Here is a young animal whom we wish to make into a rational creature. He comes to us with a large animal love of freedom and out of doors as the dearest boons of life. Surely we should begin to tame him gradually, and not require more than two or three hours of quiet each day at first.

We are suffering from a false ideal of education which has been handed down to us from the Renaissance. We seem to think that to master books is the only way to become learned, and to become learned is the object of education. Whereas

neither of these propositions are true. One can gain nothing but second-hand information from books, and the object of education is not to make men scholars. The time when a man can become learned from books alone has already passed. We live in an age of science; and observation and experiment are its fundamental methods. Our ideal student is no longer an emaciated consumptive with a wet towel about his brows, bending over his Homer in the small hours of the morning, but rather the well-rounded man of the world; one who knows books, but who knows men and affairs as well; one who has drunk deeply from every experience an honorable life can offer him; one who has ideals of action as well as thought. How absurd in the face of modern culture to teach the child the contents of a few books and think we are educating him! All our cities are becoming cosmopolitan; almost anything that can be learned from books, can be better learned from the observation of the things around us. The city in its parks, museums, libraries, art galleries, theaters, sermons, business, etc., offers a liberal education to every one whose mind is open to receive it.

The charge of impracticality can always be preferred against book learning: It is less often called up by our every-day experience; its lessons are less easily applied; they are acquired with greater difficulty and more easily forgotten than lessons from observation and experience. It is at least as important that a child be able to observe well, as that he be able to master books. Observation is usually of things right about us, which will touch our lives the oftenest. The problems which life gives every man to solve cannot be solved from books. He must learn to study from nature herself, those things on which his success depends. *That man is best educated who best knows how to solve his life problems, drawing on every resource everywhere that can help him to that solution.* But knowledge in its largest sense is a very small part of a well rounded education. It is surely as worthy an aim to admire a beautiful picture or poem as to know how it was constructed; it is as much to love a great good man as to know his biography; and to be able to do a thing is surely greater than to know how it is done.

There are five aims to be gained by a well rounded education: 1. A good physique; 2. To know what our life requires us to know; 3. To be able to do whatever we need to do; 4. To admire the beautiful; 5. To love the good.

If the child is to repeat the history of the race, nature must be his first environment. Nature has everywhere been man's first teacher, and on the complexity of the reaction she demanded has largely depended his progress. Just as the savage has seen in the storm or the sunshine, not the action of

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a natural law, but the beneficent or malevolent action of a God or demon, so the child, looking forth upon nature, sees everywhere a nature like himself. He knows no impersonal forces, no natural laws of physics. The brier that pricks his fingers, the ivy that poisons him does it from ill will, and well deserves to be broken. The child's thinking is mostly feeling, and feeling knows only the living. Alas, that for us the day should come when we find nature a mere machine! That we should calculate its formulas by mathematics and think we have solved its mystery! If a man might *really* live, but for an hour, in such a universe of death as some scientists would make this to be, he must find life itself unbearable. The living soul would still live and find life around to respond to it. If man is indeed shut up in an iron prison; if from stars and flowers and mountains come no voices to soothe his spirit; if nature herself is a mere total of unpitying, unsympathetic forces on which man is borne along like a bubble;—where shall he find an environment for the feeling side of him? A link between mind and mind? The animism of the child still lives in us. So long as feeling gives an element to thought, it must still live. The poet, the painter, the musician, the child will feel it most, but he who is not entirely sunk in self must find in nature some answering chord which tells us we are all akin. We find a society in chairs, pictures, books, anything near us in accordance with this principle. But to the child, whose life is so largely feeling, all these things are intensified, and in nature and living things he finds the fullest response. Here, in woods or flowers or animals, he sees companions, and his imagination seeks to fathom the motives of their actions and the pleasure of their lives. Could anything cultivate the heart more than this living world and make it responsive alike to the fancies of the poet and the teachings of religion? Here in this primitive nature love are the roots of the love of the beautiful and the good. The nature lover is always reverent, he believes naturally in the divine. The child's attitude combines the religious and scientific. All true science must be guided by love and reverence.

The child is interested in all the objects around him, but especially the living things. His attitude toward them is truly scientific, he observes them from every point of view and subjects them to all sorts of experiments. He is interested in everything new. Notice how soon anything going on in the street will call a crowd of children. When I was teaching in the country the children used to ask if they could n't go to the windows when a funeral procession was going by, or if I would n't give them a longer recess so they could see it. The child is deeply interested in what he sees and does not soon for-

get it. Excursions and travel should fill as large a place as possible in this period of middle childhood. But science, especially the field sciences, botany and biology, should be the first studies.

Another sad thing of our school system, especially of our city schools, is that, when the children have finished them, there is nothing which they can do. The boys have not learned to use tools or make things, the girls have not learned to cook or sew. Our present system is making an almost absolute breach in sympathy between the classes. If the children of the rich had learned in school to carry on work which forms the occupation of laboring men, would there not be a broader base for sympathy between them? Would it not tend to break down the prejudice that manual work is degrading? Should it not be true that the men who stand at the top have actually passed through the stages in which the laboring men still live? Just as the foremen in the shops know the trades of all the men under them.

And then, too, here would be given the first stimulus to many a youth of real ability, who would develop later into a skilled workman or master. The youth going from school would find the acquirement of a trade much easier and his ultimate perfection higher, because of having learned to make these adjustments in the plastic period of youth. At present the boy does not get a touch of manual work until the time for forming ideals is largely past and the trades are left out. If the child is to repeat the history of the race he must be a workman before he is a lawyer or doctor. Is it not as well worth our while to learn to do all the race has learned to do, in some crude form, as to know all the race has known.

Yes, you say, but our curricula are already overloaded and our teachers and scholars overworked; how can we find time or strength for these additional burdens? As I have taught and visited schools, I have been more and more impressed with the fact, that the children do not work more than half their time, and the great problem of discipline is how to keep a child still, who is doing nothing. The children are not to blame for this: five or six hours of hard mental work a day is as much as most *men* can stand. The question irresistibly suggests itself, why not have a half day session if the child can do all his work in half a day? It would seem that he could not, if it had not been amply tried. But it is well beyond the experimental stage already.

I make a few quotations from Chadwick's "Health of the Nations."[1]

[1] Richardson's Condensation, Vol. 2, p. 170-176.

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"The general results stated have been collected from an experience during a period of from twelve to fifteen years of schools, comprising altogether between ten and twelve thousand pupils.

"From such experience, it appears that the general average school time is in excess fully double of the psychological limits of the capacities of the average of the children for lessons requiring mental effort."

"The preponderant testimony is, that in the same schools, where the half-time factory pupils are instructed with the full-time day scholars, the book attainments of the half-time scholars are fully equal to those of the full-time scholars, *i. e.*, the three hours are as productive as six hours mental labor, daily. The like results are obtained in the district pauper schools."

"When book instruction is given under conditions combining bodily with mental exercise;[1] not only are the book attainments of the half-time scholars proved to be more than equal to the full-time scholars, but their aptitude for applying them are superior, and they are preferred by employers for their superior alertness and efficiency."

"Mr. Charles Paget, M. P.,[2] from Nottingham, tried a similar experiment in the village school on his estate. The school was divided into two sections, one of which was kept to the ordinary work for the ordinary hours, the other for half of these hours only, the rest of the school time being devoted to work in the garden. At the end of the term the half-time, or gardening boys, had excelled the others in every respect, in conduct, in diligence," and in the results of study.

In the Worcester Model School, the pupils work a half day only and easily keep abreast of the children who are in school all day.

In our truant schools the children spend only a half day in school, and the other half in working in the garden or the shop. Yet these scholars go back after six months or a year in advance of their classmates, who have gone on for the whole day in the common school.

Mr. Kline in studying truancy last year was led to a similar conclusion,—that a half day is better than a whole day.

Our whole school system from top to bottom is unnatural; it makes too wide a gulf between school and the life for which it is supposed to prepare. Like the scholars of the middle ages we learn our grammar first in the hope that some ten or fifteen years afterward we may put it in practice. If we will but con-

[1] The same, p. 181.
[2] Taine's Physical Education.

sider it, any of us can satiate our craving for knowledge by one or two hours hard reading, and gain more facts than will ever bear fruit in our lives. I believe the great curse of our higher schools is over-feeding, which leaves us no time or strength for mental digestion, and as a result there is no independence of thought, and no idea of putting the precepts learned into practice. The student goes to college like a sack to be filled. The scholar, far from being a man of leisure, is the one man in the world who often has no hour of relaxation from seven o'clock in the morning until eleven or twelve o'clock at night. He has no life. It would be nature's way to learn something when we need to know it, not to swallow whole libraries in the hope that they will sometime be useful. If school learning is something like a set of rules to be put in practice, it is important that we have some life experience, in which to try them before school is over. It is no wonder that so few of our great men were noted scholars.

Even if the child should not gain as much book learning in half a day as he does in a whole day, we have sought to show that he may gain a great many other things which are quite as valuable. Not the least among which is that he will gain in power to concentrate his attention rather than learn to spread a little labor over a great deal of time.

I wish to make acknowledgments to Dr. Hall for proposing the problem and for many suggestions in this work, and to all those who have either served as subjects in experiments (several of which are not here reported), or sent replies to the syllabus, and especially to Miss Lillie B. Williams for the admirable returns received from the New Jersey State Normal School.

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NOTES ABROAD.

During the past academic year the writer has made a pedagogic trip through Germany, France, and Great Britain. His attention was directed mainly to university courses bearing on psychology and pedagogy, and the aim was to meet men and get ideas. Arriving in Germany at the close of the summer semester only a few days remained of the lectures. These days were spent at Giessen in Hessen, the inopportune deaths of Professors Wolff and Meyer at Bonn, and of Prof. Preyer at Wiesbaden having rendered futile the previous stops. The following notes are left in unelaborated form as better suiting the informal nature of the trip and the personal character of the facts.

During the summer semester of 1897 the only course of lectures on child study in the philosophical department of any German University was that on "The Mental Life of the Child" by Prof. Karl Groos at Giessen. Groos's study of play in animals has been followed by a study of play in children and this subject has led him, in order to familiarize himself with the whole of child life, to gather the material for the course above mentioned. Being unique in Germany, the course was announced with many misgivings as to its success, but it was attended by a considerable audience of interested students. Prof. Groos, who has this year accepted a call to Basel, is a young man (b. 1861), hungry for information from abroad and eager to avail himself of new ideas, an enthusiastic worker, and a man of great promise. His second volume on the plays of children is now ready for the press.

Prof. Hermann Schiller (b. 1839) is a man of wide experience and author of numerous pedagogical writings, loquacious in conversation and reminiscent in lecturing. He is sometimes classed with the Herbartians; but, although adopting a sort of concentration idea and favoring the formal steps, he repudiates the name and belittles their influence. According to his view, the Herbartians in Germany are a vanishing quantity, their great leaders (Stoy, Frick, Dörpfeld, etc.) dying and leaving too little interest and energy in the younger generation to continue their work. Schiller, in company with Ziehen in Jena, is editing a new series of pedagogical and psychological monographs and, like Erdmann (formerly in Halle and now in Bonn) has done some experimental work himself, with the result that he "don't think much of it all anyway." The united library of the gymnasium and university seminar is exceptionally large and well supplied with special pamphlets representing the newer ideas and current pieces of work. The able professor of modern languages, Dr. Dorfeld, is librarian, and has charge of the initiation of candidates for secondary schools into their work in French and English.

Arriving at Jena in time for the vacation courses of the Rein School, I had expected to find there the cream of thought and new ideas rising to the surface and ready to skim. But the great percentage of strangers from abroad has turned the lectures into a school for teaching German to foreigners. For this purpose it is excellent, but I found only one course that seemed to have any material in it more recent than ten years old. This work was by Dr. O. W. Beyer, who has made a specialty of manual training. He had a room full of books on the subject, pasteboard models, and diagrams, and at the close took his

class up the Saale valley to Pössneck to examine one of the best organized school-gardens in Germany. There on a plot of ground prepared in 1895 at a cost of $750 and requiring an annual outlay of only $75, six hundred pupils have each his or her separate garden patch, and every day between 5 and 6 P. M., they come to weed, water, hoe, train or otherwise attend to and reap what they have sown. The central path in the garden is reserved for the parents who come there to promenade and enjoy the sight as well as encourage their children and help them carry off the armloads of cabbages, potatoes, lettuce, onions, turnips and flowers for home consumption. Besides these separate beds, the garden contains a tree nursery, a frame shed for class use (as the school building is fifteen minutes distant), separate sections for industrial plants, hemps, flax, wheat, corn, rye, etc., for poisonous plants and noxious weeds, for alpine or mountain flora and for swamp plants. As far as possible, plants that grow together in nature are kept together under natural conditions in the garden.

In a new edition of Rein's "Theorie und Praxis," Dr. Beyer has been commissioned to revise the entire curriculum from this new standpoint of handwork, bringing everything into organic relation with it and making it the center out of which the other school subjects grow. For these ideas, compare his "*Naturwissenschaften in der Erziehungsschule*," (Langensalza).

The new building for the Practice School at Jena is completed and the school expected to move in last Easter. In addition to three smaller classrooms, there is one larger classroom for the *Probelektionen* when all the seminary attend, one large room for the Thuringian School Museum and one for the Seminary Library, beside office and three living rooms for the training teachers, and in the basement, gymnasium, bath and workshop. The building is of brick and sits back from the street a considerable distance and is surrounded by the school garden. It is unique in Germany, all the other universities concerning themselves exclusively with gymnasial pedagogy and therefore utilizing a regular gymnasium as practice school.

Taking a suggestion from Helena Lange, E. A. Fabarius proposes in "*Die allgemeine Dienstpflicht*" to require by law of every normal girl of eighteen years of age three years' service in housework, nursing, sewing, etc., corresponding to the obligatory army service for the men. Another proposal in "*Der freiwillige Dienst in der Wirthschaftlichen Frauen-Hochschule*" by Ida von Kortzfleisch plans to give girls of 20 years who have passed through the *Höhere Töchterschule* a training in woman's work. Both of these proposals merit attention.

Trüper's Institution for abnormal children is ideally situated on Sophienhöhe, overlooking Jena and the valley of the Saale. Each pupil is studied individually and a careful record kept of physical and psychical tests, treatment and reactions. A series of such life histories or "pedagogical cases" (corresponding to the cases of the lawyer or the doctor) is being published in "Kinderfehler" (Langensalza), which seems to be almost the only child study periodical in Germany.

Director Ufer in Altenburg, who, nervous himself, has made careful studies of nervousness in school children, and has recently reissued Sigismund and Tiedemann with notes, seems to be the coming leader of child study work among the German teachers. At the spring meeting of the the Thuringian teachers at Erfurt, he was to propose the formation of a German society for child study. While at Altenburg I heard him give one of the very best lessons on the 7th Commandment, developing the ideas of the family relation, its importance, mutual duties and helpfulness. He treated successfully delicate topics of the home, love, duties of children and their rights in a

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masterly way that was simple, impressive and adapted to children, without being childish. If we could have such lessons in religion in our schools we should gain much.

Prof. Fritz Schultze in Dresden is writing a "*Vergleichende Seelenkunde*," the fourth volume of which will contain a genetic psychology.

One of my most charming excursions from Jena was with Dr. Lindley to the old homes of Fröbel on the border of the Thuringian Forest. We took the steam car to Rudolstadt, famous for its Anchor building blocks that have delighted millions of children. Beside the building blocks, Richter has a chocolate and candy factory, a bathing establishment and a sanitarium, a patent medicine laboratory and warehouse, lives in a palatial castle and owns nearly all the ground on which the city stands. Keilhau is about an hour and a half distant. Most of the old buildings are still standing, although much added to. The school is now converted into a regular Realschule and has lost entirely its original character of experimental school. It is situated in as lovely a valley as exists in Germany. We can understand some of the love of nature that breathes through the pages of "The Education of Man" when we look upon the surroundings in which Fröbel wrote and worked. Fifteen minutes' walk beyond the school brought us to the top of a ridge from which a magnificent panorama of the whole valley in which Blankenburg lies and the northeastern part of the Thuringian Forest stretched out like a map. In Blankenburg, Fröbel's old home is now a bicycle repair shop and the house in which he established his first kindergarten is part of a public school, what was the "*children's garden*," according to Unger's drawing, laid out with separate flower beds, is still a garden but not used by the school. We found a number of old pupils of Fröbel who could tell anecdotes and experiences.

The old university building in Bologna is exceedingly interesting with its historic clinical amphitheater, its court of honor covered with the names of its illustrious former members arranged by nations, and its new halls with memorial tablets to its women professors. In front is a marble statue of Galvani performing his epoch-making experiment on the frog.

Our School for Classical Studies at Athens is engaged on very important excavations on the site of old Corinth that have been so far successful that the site of all of the chief public buildings in the ancient city has been determined, although when the excavations began the only visible remains were a few ruined pillars of an uncertain temple. At Athens the Parthenon is being rescued from what would soon be certain destruction by the weather and by earthquakes. New marble girders are taking the place of the old blocks that had become rotten with age and the loose pieces are being braced with iron.

In Vienna there is nothing new of interest in pedagogy at the university. Prof. Vogt, the president of the *Ver. f. w. Päd.*, is an able logician but aims at nothing more than clearness of exposition of Ziller's work. The university is in no sort of sympathetic rapport with the schools and therefore exerts no noticeable influence on them. On the other hand, the Austrian teachers look back gratefully to Dittes who was opposed at every turn by the present professor of pedagogy. Dittes's work is continued by Hannak, whose interest in pedagogy, however, is chiefly historical. The Pedagogium is unique in being a continuation school for city teachers in office.

Every student of school hygiene knows of Prof. Leo Burgerstein, but perhaps not many know that he is by profession a geologist, which

subject he teaches in a Realschule, giving only his spare time to the study of school fatigue, etc. He was the most helpful man I met in Vienna and gave unstintingly of his time and resources, going over his more than 150 correspondents in all parts of Europe and advising what men to see and what places would be worth visiting. His pioneer work on school fatigue was carried on in the face of great discouragements and utter lack of cordiality on the part of the school authorities. The data obtained were worked over to a much greater extent than their reliability justified, in order, as Burgerstein said, to demonstrate what could be done if data were taken in greater quantity and under more cordial conditions. Burgerstein was busy on a report on *Wohlfahrtseinrichtungen* to be presented at the Emperor's jubilee in May of this year. After this he intends to return to his previous investigation into school fatigue.

At Breslau, Ebbinghaus was lecturing on experimental psychology and pedagogy. He attracts students by his own personality and vivacious, lucid style, rather than by any material facilities. For, there was no laboratory to show and no research was in progress, except the one being conducted on school fatigue by a special commission of which Ebbinghaus is the most prominent member. In fact, he says the German students that come to him do not want to become psychologists but wish only a survey of the field, so he aims to meet this want, giving up original research since married life makes impossible that regularity and uniformity of life necessary for a reliable experimental self-study of mental work. He gives up all his spare time to his editorial labors and writing his new book. He wishes some one would take his work on memory more in earnest and carry it forward, as he believes it is entirely possible to do so.

Dr. Stern, Prof. Ebbinghaus's assistant, is a promising young private docent of whom I heard good report.

Genial, sociable almost to a fault, and so well known that even the dogs wag their tails and prick up their ears as he passes, Hermann Cohn, better known as Augen-Cohn, has to stop when going along the street, every five or ten minutes, for personal exchange of friendly words with his thousands of acquaintances. He has been a specialist in eye diseases for over thirty years, introducing many reforms in manipulations and improvements in operations. He has lectured without pay for a quarter of a century at the university.

Leipzig undoubtedly has now as fine university buildings as there are in the world. The money has been well spent, without extravagance, but everything of real value has been secured of the best quality. The electrical lighting is excellently arranged. The light thrown by reflectors placed under the large arc lights is a second time reflected from the white ceiling and dispersed evenly over the entire room. It is easier on the eyes than daylight, because of its evenness.

Prof. Wundt, greater now as philosopher than as psychologist even, appears at his best at present perhaps as a lecturer. His masterly presentation of Greek philosophy and race psychology last winter was heard by a crowded auditorium of over four hundred. The new rooms of the psychological laboratory, fourteen in number, arranged according to his plans, are by far the most extensive and complete in Germany, and contain many historic pieces of apparatus as well as some very new and costly ones. The new psychology has many opponents still in Germany. Men such as Paulsen in Berlin, Erdmann in Bonn, and Fischer in Heidelberg minimize its advances or, like Heinze in Leipzig, believe that Wundt will yet live to see a great reaction, and that this revulsion in confidence in the new psychology is now well begun. To

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all of these sceptical misgivings Wundt smiles placidly, full of confidence and clear as to the grounds of his faith.

Flechsig is an extremely interesting man to meet, full of his new discovery of "*Denkorgane*," and ready to talk to any one who is interested and appreciative. The whole matter is in a state of flux in Flechsig's own mind. One time he will tell you he is sure of 30 centers positively demonstrable, and a few weeks later he is just as sure of 40. This unsettled condition of his ideas is retarding the issue of his new book, for which the plates alone are said to cost fifty thousand marks.

Volkelt seems very bright and keen, perhaps a little narrow, but an excellent man to work with. He was conducting a good seminary in Herbart's *Allgemeine Pädagogik*, with thorough elucidation and lively discussion.

Heinze speaks indistinctly and fails to look you in the eye, but is a charming man to meet and has written an extremely serviceable continuation of Ueberweg's History of Philosophy, giving an account of current philosophers.

Poor old Prof. Strümpel still lectures on the Criteria of Truth. It is a pathetic picture to see the feeble old man come in leaning on the arm of his famulus and sit down to continue his course, "if God permits him to finish."

Prof. Marcs had an excellent seminary in historical method. The aim was to train in the weighing of evidence, sifting truth from error and dealing directly with the original sources. The period treated was the March days in 1848 in Berlin, when the king's vacillation was encouraging lawlessness.

The professors of pedagogy in Germany, with perhaps the exception of Rein, seem to have no interest in the study of educational problems, and nowhere did I find them doing anything themselves along the newer lines. Several, while lamenting it, admitted frankly that pedagogy was a dead subject at the universities, and that they looked to America for new inspiration.

Halle has a splendid set of medical buildings, and makes a great showing with such men as Hitzig, Roux, and Bernstein.

The most American professor in Germany is perhaps Conrad, who has exercised the greatest influence in the education of many of our leading economists. He conducts a seminary, in which the interest is intense and maintained, the discussion always lively and earnest. These results are due solely to his pedagogic tact.

The Frankeschen Stiftungen are always a mine of pedagogic wisdom, if one has time enough to stay for two or three weeks. In less time one cannot form any adequate conception of the schools. Frick's Seminarium Præceptorum is continued under Director Fries.

Berlin is badly off for a satisfactory university building, and after being accustomed to the commodious and hygienic Leipzig palaces, one is painfully impressed with the poor lighting and bad ventilation at Berlin.

Stumpf is a wonderful man in his field and he keeps pretty close to it, thoroughly German in his specialistic ideas, and with no interest for anything else. His assistant, Dr. Schumann, is an able, industrious and obliging worker, who is sure to rise to eminence in his subject. The laboratory occupies four rooms, dark and cramped for space, but containing several pieces of apparatus of much interest and adapted to the special investigations under way on sound. Some new work on the tendency to group similar objects into units and the influence of this on the formation of judgments of differences is in progress.

The new professor of pedagogy at Berlin was cold, his lectures were

delivered in diplomatic language, containing no new ideas, and he himself was in no sort of rapport with his class.

Paulsen was disappointing. One expects a good deal of such a tremendous physique and that grand, broad head, and he has done great things in his published works; but his lectures on pedagogy, while the best in Germany at present, are just about the same as he was delivering eight or ten years ago. No wonder the professor loses his enthusiasm.

Max Dessoir is a charming personality, a "ladies' lecturer," polished, graceful, always prepared without notes and always with fresh material. He puts one at one's ease immediately, and you feel as if you must have known him before. He practices what he preaches. He was lecturing on literature and spoke of the ideal sort of conversation between those who meet on terms of perfect equality, as in the French salons of last century. Helmholtz's evenings in Berlin were the last thing of that sort in Germany. Our modern use of titles and even the sycophant "*Sie*" in address makes such perfect freedom and feeling of equality impossible. He takes 5–6 hrs. in preparation for every hour of lecture, and never attemps to carry more than seven hours of lectures per week. When he has worked a subject up in lecture form satisfactorily he publishes it, and then does not lecture on it again for some years, until it has sprouted new ideas. In this way he keeps fresh and growing.

Simmel is another of the young docents in Berlin who are doing some original thinking and attracting students by their real merit.

Baginsky is getting out an entirely new edition of his *School Hygiene*. He "just lectures for his own amusement," and does not think as much of other people's work as of that done by himself.

Lassar and Behrends had advertised public lectures on syphilis for students of all the faculties, and one of the courses was held in the great auditorium, capable of seating nearly 500. But both lectures were interspersed with coarse, indecent jokes, and pandered to a morbid curiosity, without one word of awakening to higher views or nobler motives. They were sensational, but in no way pedagogical or inspiring.

Dilthey gives a clear, good note book, as the German student says, and pounds it in with a ridiculously monotonous left-handed gesture. Indeed the automatisms of the professors are extremely interesting. Paulsen carries a pencil, which he places carefully on the desk when he begins to speak. In about five minutes or less he picks it up as he would a new thought and plays awhile with it in his hands, and then as carefully places it on the desk again just as he finishes one topic and is about to go over to another. Wundt makes only one gesture, an ambidextral outward movement with his hands as he leans on his elbows. Eucken looks at the ceiling. Richet makes a continuous double-handed gesture of depreciation, as much as to say: "This is all very trifling and trite, I know." Izoulet rubs his hands at the beginning of his lecture as if getting ready to fight, and then holds up his right hand as if he had the thought between his thumb and middle finger. Giard puts his hands behind his back and promenades up and down the platform, looking at the floor. Raymond in Charcot's old clinic in the Salpêtrière holds the idea between the thumb and middle finger of his right hand, and then springs up and down in his chair, as if on horseback, going higher and faster in proportion to the intensity of the idea, and sometimes getting one foot into the seat of his chair and actually sitting on it as on a spring.

Gutzmann (Berlin) is a specialist of international reputation. In his recent pamphlet on early reading he has brought out the same

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idea that Dr. Hartwell so graphically portrays in his famous report of 1894; viz., that stuttering increases 3 to 4 fold in the 7th year, owing to faulty methods in school. The phonic methods of Graser and Krug are commended with slight modifications. He has been making some experiments with telephone sounds, and he finds that transmitted nonsense syllables cannot be distinguished. This shows what important apperceptive helps are the context and the overtones. Any one who has had to talk with a foreigner through a telephone will be able to confirm this from his own experience.

Inspector Piper (Dalldorf, near Berlin) teaches feeble-minded children to speak correctly by making them conscious of the right position of the vocal organs, and developing from this a sort of visible speech, simpler than Dr. Bell's. He has recently issued a child's primer on this plan.

E. Pappenheim is the very pleasant and able head of the Kindergarten Society of Berlin. This society very wisely opposes the transfer of the kindergarten to the school authorities on the ground that its methods are not ready yet to be stereotyped, but must have freedom for development, and that is not possible after it passes into governmental control. Child study, Pappenheim says, is the method of developing the kindergarten, but "always let us insist that Fröbel shall be understood before his ideas are modified or developed."

The Hamburg Drawing Teachers' Association is the center just now of the greatest activity in the reform of drawing methods in Germany. They are going at it from the standpoint of child study, and last spring organized an extensive international exhibition of children's drawings in the Kunst-Halle of Hamburg. They have been collecting literature, and have issued several pamphlets, among them one on the developing of artistic taste through the study of pictures in school.

Although Kuno Fischer refuses to have a psychologist at Heidelberg, and although Kraepelin himself declares he is no psychologist, but an alienist, it still remains the fact that Heidelberg is one of the best places in Germany to study psychology. Kraepelin's chief labors during the last ten years have been directed to the problem of mental work, its conditions, individual differences, the influences of drugs on mental activity, and the hygiene of work. This problem of mental work is the essential question in pedagogical psychology, and hence, too, Heidelberg is the best place to study experimental pedagogical psychology. There are two able assistants in the laboratory, one of whom, Dr. Aschaffenburg, has already done notable work in exhaustion, the other, Dr. Michelson, has made new investigations on sleep. The laboratory includes only three rooms, but contains many new and ingenious pieces of apparatus. Dr. Nissl's work in histology promises to be revolutionary of the neuron theory.

Bernheim's pamphlet on "Der Universitätsunterricht und die Erfordernisse der Gegenwart" (Berlin, 1898), touches an important subject greatly needing discussion. The reform proposed is, in brief, as follows: (1) The Private Courses of lectures (privatim and privatissime) of six hours or more per week should be abolished, and in their place should be substituted (2) Short Courses of orientation (one to two hours), much condensed, giving chief view-points only, with reference to more important literature; (3) Practical Exercises from first semester onward (two to four or more hours per week), to initiate students into general scientific and specialist observation and thinking, and accustom them to clear formulation of their thoughts orally and in writing. The present existing seminars will not be changed in their arrangements, but will be given a firmer organization and strengthened rela-

tions to one another, and to the whole of university teaching. They are all to be arranged in two grades, for beginners (Proseminar), and for advanced students (Seminar), and all will acquire greater importance in proportion as they are pushed into the foreground of university work; (4) combination of systematic presentation with practical exercises, *e. g.*, in archæology and art, history, natural science and medicine by demonstrations, exercises, excursions, etc., in connection with the lecture course. Similar arrangement is possible in the humanities. In the Proseminars the students (a) would learn to consult libraries. "The lack of knowledge of books is really a shameful fact in our academic life to-day." (b) They would come at once into contact with the professors, and would feel the stimulus, and the teacher could the more easily get into rapport with the hearer and advise him, help him to supplement his knowledge where he is ignorant, and test how far his own method of work is pedagogical. (c) They would be much better prepared to enter the seminars, which would thus be raised in grade. Single professors cannot start the reform in practice. It must first be discussed generally, and then introduced simultaneously everywhere. Examination ordinances must require, for doctor's degree and for state examination, the production of work done in each year of university residence, and signed by docents and dated. A year and a half to two years of Proseminar exercises should be required, and one year to a year and a half of original investigation in the Seminar.

Alfred Binet lives in a modest house a short distance out from Paris, and here he works undisturbed, free from any obligation to lecture or examine students, and under no limitations as to work. For, although director of the psychological laboratory of the Sorbonne, he is relieved of all care by his two assistants, and devotes himself entirely to his research work and to publication. It is very different from the work in Germany; for Binet has no seminar, and does not expect to train psychologists. Rather, he has gathered about him a half dozen or so young men who work with him, as if in partnership. The most gifted and prominent of these younger men is Victor Henri, who in every way is Binet's right-hand man. A Frenchman by birth, Henri has spent much of his time in Russia, where he married, and in Germany where he studied with Müller at Göttingen.

Binet & Company are working up individual psychology, and have developed about 70 tests applicable to pupils in public schools. Of these about half are "quite satisfactory." They go every fortnight to two normal schools out from Paris and put the students through the tests. They have been doing this for about two years, and propose to work up the results with reference to seasonal changes and weather influence. Nearly all the tests they commonly use aim to reveal the relation between physiological and psychical functions. Among the usual tests are the following: (1) rank in class, (2) memory for numbers, (3) circumference of chest, (4) height, (5) weight, (6) running time, (7) reaction time (simple), (8) reaction time with choice, (9) counting "petits points," (10) diameter of head, (11) fatigue curve by ergograph, (12) pulse, (13) breathing. They aim also to test the imagination by such questions as these: (a) The teacher takes a square piece of paper and folds it diagonally, and folds the resulting triangle again. Then with the scissors a piece is cut out of the last triangle. Query: what will be the resulting shape when unfolded? (b) A strip of paper is twisted once and the ends pasted together. Then with the scissors the strip is cut around on the middle line. Query: what will be the resulting form? If the resulting ring is similarly cut along the middle line, what figure will

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result? The pupils are also asked to describe simple objects distributed to them, *e. g.*, a pen, or a double sou. Lately the camera has been used to photograph automatisms. It is proposed to publish the results of these studies in a new series under the title *Bibliothèque de Pedagogie et de Psychologie*. The first volume of this series is out: *La Fatigue Intellectuelle*. The second is announced on *L'Education de la Mémoire*.

Théodule Ribot, although associated with the Binet school, is an independent worker, and undoubtedly the most reliable and ablest psychologist in France. There is considerable jealousy between the two parties, and neither thinks very highly of the other's way of working.

Ribot was born in Brittany in 1839. He is short, frail looking, with little, nervous twitches of the head and eyes. In answer to the question, why don't the French do more work in psychology in the university? Ribot replied that the work in the psychological laboratory did not count toward the degree, nor was it included in any examination for the degree. Secondly, the French have not the perseverance and patience necessary to accurate introspection. Ribot says that, at the Collége de France, he must count on the usual point of view of his audience being that of logic and intellect. They do not comprehend the emotional life, and would not understand him if, as he would like, he should address them from the standpoint of the emotions. He has, however, great hopes of the advance of psychology by the study of the sentiments and feelings. The most promising field in psychology at present is that of attention. There are many fundamental questions raised by Wundt's position, by Münsterberg, by James, and others, but much can also be solved by experiment.

Jules Soury is also an independent worker, lecturing on psychology in the Ecole des Hautes Etudes. Perez, who used to write so tediously on child study, has become a melancholiac in an asylum outside of Paris. Buisson is doing very good normal school work in pedagogy at the Sorbonne, reading educational classics, and having essays written on them.

Having opportunity to accompany one of the medical inspectors on his visit to the schools, I saw something of the surface routine. Dr. Mangenot has drafted a project of a law requiring daily visits and individual examination with separate individual bulletins for each pupil. All the pupils are to be weighed and measured twice a year. These data are to furnish the basis for indicating to the teachers (1) how to seat the pupils, (2) which to relieve of home-work or gymnastics, (3) which need medical attention outside, (4) which need "preventive medication" (*i. e.*, supplement to home diet, *e. g.*, cod-liver oil, etc.), (5) which pupils should join the "colonies scolaires."

Izoulet was lecturing on Rousseau to crowded audiences of students, society women, professors and men of affairs in the Collége de France. There were many demonstrations of approval and disapproval. "Under the old order of things, men were chosen by aristocracy of birth; under the new order on the basis of a diploma by examination. *But only the mediocre pass an examination.* Original thought does not help one to pass. We are training for mediocrity."

In the art academies of Paris all students, beginners as well as veterans, drawers in charcoal as well as painters in oil, and modellers in clay, work from the human figure. Nothing else is so interesting, so adapted to all stages of progress, so readily criticised and mistakes so clearly felt and appreciated. On the Saturday visit of the professor, the weekly sketches are criticised and marked. Among these are often to be found excellent pieces of work, with much simplicity and depth of feeling.

An exceedingly interesting and valuable work is being done by Dr. Edgar Bérillon in his Institute in Paris, where he cures common faults of children, *e. g.*, onychophagia, onanism, lying, laziness, fear, etc., by the method of suggestion. Every teacher must be struck by the proposition laid down by Bérillon that educability is measured by suggestibility. What an unused power in the school room, where the ideal so often is to reason and to compel by authority. (*Cf.* article on "The method of suggestion in the cure of faults" in the May number of the North Western Monthly.)

Sir Joshua and Lady Fitch were charming in their hospitality, and eager to show their warm interest in everything relating to American education. Fitch's new book on "The Arnolds" is worthy of his former fame and has received the most diligent care and study in its preparation.

Whether on such a flying trip you get much or little from a man depends on how you approach him. If you have read any of his writings, you have the key to his heart. Nothing perhaps pleases a man more than to be sought out by one of his unknown readers and find that his thoughts have taken root and awakened interest. I have never found any one unwilling to talk about his published writings, their prospective new editions, and their circulation in America. It makes a great difference also whether you know anything of the man's work and line of interest, and whether you have done any study along that line yourself. Professors are generally pleased to discuss their ideas with intelligent and interested fellow-workers.

Prof. Sully has a grand opportunity if he will rise to the occasion. The child study people in England are looking to him for leadership, and there is no one in whom the teachers seem to have more confidence. He has it in his hands to develop the subject as he thinks best, but he has, unfortunately, been prevented by ill-health from taking a prominent part of late in the British Society for Child Study. It is high time that the development of sagacious and fruitful lines of investigation was lifting the work from the low plane of scrappy, rambling anecdotes. Such leadership requires boldness and insight. Prof. Geddes, of Edinburgh, has the qualifications, and if he were to throw his whole interest for a few years in that direction Great Britain would soon be doing as much as the United States; for the interest is present but a leader is as yet lacking.

The Teachers' Guild in Gower Street, London, is a center for information about education. Amongst the interesting things in the library and pedagogic museum is a recently published portrait of Pestalozzi, discovered by Mr. Russel on a trip through Switzerland. It seems to be a pencil sketch from life, with a great deal more life and truth in it than any of the older pictures.

The library of the Education Department formerly in the South Kensington, has moved into new quarters in one of the side streets off from Whitehall. The department of Special Inquiries and Reports is organized under Mr. Sadler and Mr. Morant on the model of our own Bureau of Education. They have begun the publication of these reports, the first volume appearing about a year ago, and the second volume being now due.

Interest in England at present centers in the organization of Secondary Education. Shall it, like elementary education, be centralized? If so, what shall be the constitution of the new central authority? Shall it be professional or political?

Dr. Warner is the champion of the study of the child "as a natural object by the laboratory method." His new edition of "How to study children" is intended to be put into the hands of teachers and parents. He has in MS., awaiting publication, another book on "Natural His-

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tory and Child Study," a manual for teachers in training. Furthermore he has in contemplation a philosophical work in two volumes to cover the whole ground of child study and unify all that is known about children. He expected to come to this country in the autumn to lecture and examine children and report on them.

James Ward was an early champion of the new psychology when fresh from Leipzig in 1876, and urged Cambridge to found a laboratory. But Cambridge laughed at him, and is only now beginning to take it up in earnest. Meanwhile Ward has drifted into metaphysics and is now deeply immersed in the theory of knowledge and does not keep up with the work elsewhere in psychology. Two of his pupils are rising into prominence—Mr. Stout, now at work on a new genetic psychology, and W. E. Johnson, who is turning his attention to education.

Newnham College has a daintily arranged, well-lighted, new library building just completed, the gift of the Rev. Mr. Thompson.

Ebenezer Cooke, the author of the Alternative Syllabus in Drawing in the English Code, is a very interesting man. Rustic in appearance, with no higher education, although a pupil of Ruskin, a plain, homely man, by himself he is working out his subject by observing children without concerning himself much with what is being done in other countries. All of the brush-work ideas advocated by Mrs. Rowland Hill in England, and by Mrs. Ella Goodwin Hunt in this country, are taken from Cooke without any acknowledgment. Cooke caught the idea from observing Jack L—— playing with a brush, accidentally making an elliptical "blob," and then adding ears, tail and legs to make a mouse. The boy was so delighted with his discovery that he covered the paper with "blob" mice, and Cooke was equally delighted with *his* discovery, and incorporated it as the corner stone of his course in brush-work. Cooke believes in drawing from memory and imagination first before drawing from the object, thus emptying out one's misconceptions in order to get ready for learning. He is fond of quoting from Pestalozzi: "All true educative instruction must be drawn out of the child, and be germinated within it."

Prof. Patrick Geddes, of Edinburgh, is one of the most genial, original, and fascinating men I met anywhere. He is in the prime of life, forty-four years old; has had a broad training in biology, working with Darwin and Huxley, and studying in England and on the continent; has turned to sociology in his spare time, and brought into it the biologic standpoint. For three months he is professor of botany at Dundee, but for the rest of the year he resides in Edinburgh or travels. His sociologic work is extremely interesting and unique. For a while he lived with his wife in a one-room flat in the slum district of old Edinburgh. There he learned to know the needs of the poor and their privations, as well as the remedies and the possibilities for the rejuvenation of the Old Town. Eleven years ago he began University Hall, which has grown to embrace Ramsay Lodge, Riddle's Court, Blackie House, St. Giles House, and several others, accommodating more than two hundred souls. Besides this he has renovated or built eighty-five artisans' dwellings, and the Old Town is fast changing into one of the most respectable sections of the city. Property has greatly appreciated in value, and Geddes has now turned the enterprise over to a stock company called The Town and Gown Association, Limited. His idea is that higher education ought to train captains of industry who can lead the material forces into productive channels. The germ idea of University Hall is an organization of higher education, "to flower as many species of genius as possible," retaining in mutually helpful association young artists, lawyers, physicians, accountants, teachers, historians, architects, engineers, etc. For, they all contribute in their respective spheres that in which they

are experts. These people ought to be fellows or docents in the University of Edinburgh. They would contribute strength and the University would extend its influence in their lives beyond the mere lectures and examinations. This is what Geddes does in his "University," which is a self-governing republic of higher education. University Hall is chiefly scientific and literary; the new Observatory, the new Asylum, the geographical society and Museum of antiquities furnish new centers of scientific and potential collegiate development.

The tutorial assistance and higher studies immediately connected with Geddes's work are centered in the "Outlook Tower," the home of the Edinburgh Summer Meeting. Here are grouped: (a) geography, history, and social science with the co-operation of British and foreign geographers; (b) Scottish and Edinburgh history and Celtic studies; (c) Educational Museum; (d) Old Edinburgh School of Art, adapting old Scottish and Celtic designs to modern industries, decorating the students' halls, and preparing plans for a national monument in the form of a frieze representing a Procession of the Historical Personages of Scotland from the year 1000 to 1745; (e) the Publishing House of Patrick Geddes and Colleagues.

The false analysis of culture elements is destructive and vicious, like the analysis of foods into C, S, Ph, etc., or into carbo-hydrates and the like. These are not foods, but the symbols of hades and death. Much of so-called biology is really necrology, for it is the study of death. The specialists in science are at the ash-heap of culture—the dead past. One rag picker finds old glass and china—that is the archæologist; another rakes up some fish or chicken bones or some feathers—that is the anatomist à la Prof. Huxley; another finds some stale flowers or dried leaves—the botanist; another some half-burned coal or slate—the geologist; charcoal and some sulphur are picked up by the chemist; letters and scribbled MSS. are raked out by the historian; and the antiquarian finds some old clothes, tin cans or bits of furniture. On the other hand, how different is real culture, not analytic but synthetic, not of death but of life. Give the children food instead of charcoal or carbo-hydrates. *Vivendo discimus.* Education arises out of life. Pupils must be fitted for the activities of life by actually sharing them; *e. g.*, school accounts, book-keeping, decoration of school building and school grounds, etc. Cecil Reddie's school at Abbotsholme, England, is working out its salvation inspired by these ideals. The individual and competitive spur to study becomes more than replaced by the co-operative and social one. Education is not merely by and for the sake of *thought*, but in a still higher degree by and for the sake of *action;* hence each course of scientific study is not merely related to those dealing with the other sciences, but in even more immediate degree to the corresponding arts of life. In the school of the future, as in the old churches of the Middle Ages, the books will be few but the pictures well-nigh infinite.

How shall we reach the fuller perfection of the human hive? The proper relation of man to woman is best expressed in chivalry—the provisional religion of Western Feudalism. The boy's sword and the girl's doll furnish the starting point for the educator. Let the boy have his fling with war and fighting. Better there than afterward on Kaiser's throne or in the senate chamber. Every age of chivalry follows a period of decadence. The evolutionist education aims at the remoralization of the sexes. Its ideal is "women strengthened and trained by men, whom they have trained and strengthened."

The spirit of Geddes's ideas on education is best obtained by reading "The Evergreen, a Northern Seasonal" (Patrick Geddes and Colleagues, Edinburgh.)

HERMAN T. LUKENS.

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LITERATURE.

An Autobiography. (Gottfried Keller).

Psychologists and Pedagogues have at all times highly esteemed autobiographies written by great men. Not to mention the innumerable "Journals" which have been read with great interest, especially when one encountered therein some extraordinary character, as for example that of Marie Bashkirtseff, documents of real value have been presented in the *Confessions*, by Rousseau, *Dichtung and Wahrheit*, by Goerthe, *L'Histoire de ma vie*, by George Sand, the *Autobiography* of Stuart Mill.

The object of these pages is to speak of another book which has been well known in Germany for many years, although scarcely appreciated by any other but literary people. It is "Der Grüne Heinrich," an autobiography of the great Swiss novelist, Gottfried Keller, who died in 1890. This book is worthy of the special attention of all those who are interested in the psychology of children. It is impossible for me to treat "Der Grüne Heinrich" in full here, and I can only present the character of the work in a few words.

First of all, something about the author. Gottfried Keller was born in Zürich, on the 19th of July, 1819. When he was five years old his father died. In accordance with his father's special wish the boy was first sent to a free school (Armenschule)[1] and, later on, to a manual training school. After having been expelled from school because he had taken an active part in the revolt of a class against an unbeloved teacher, he took up painting under a so-called artist, who then lived in Zürich. Later on he continued under a better master, his intention being to become a landscape painter. At the age of twenty he went to Munich, but returned three years later without having been successful in his work. He then received a scholarship from his native canton, which was to enable him to travel in the Orient, after a year's preparation in Germany. Keller was so much pleased with the latter country that he remained there; first at Heidelberg, where he attended the lectures of Hettner, on Literature, Esthetics, and on Spinoza; those of Ludwig Häusser on the History of Germany, and the famous lectures of Ludwig Feuerbash, in the city hall, on the Essence of Christianity (Wesen der Christentums). Then he went to Berlin, where he was very frequently seen at the theater. In 1855 he returned to Zürich where he lived in poverty. In 1861 he was elected secretary in the employ of the State (Erster Staatsschreiber). In 1876 his literary greatness had at last been recognized. He then resigned his political office. He died on the 15th of July, 1890, mourned by all Germany.

Keller's works consist mainly of short stories in which he sets forth his philosophical ideas. He is a most minute and perspicacious

[1] *Armenschule:* A school where pupils paid no tuition. Such schools were rare at that time and were attended generally only by poor peoples. The one attended by G. Keller had been founded in Zürich by some devoted citizens in the year 1786.

observer. He looks upon the world from the standpoint of sound realism.

He makes this concession to idealism, that there is in man an impulse to do what is right, but it is immaterial to him whether that impulse is indirectly of utilitarian origin, or whether it is aprioristic. It exists, it is *real*, and consequently it belongs to realism as much as it does to idealism. But when he asks where the good is that he is striving to reach, and what source it springs from, he pronounces himself very decidedly against idealism. The good to which man can aspire is in nature, on earth; it is there that he must look for it, and not in heavenly regions. In a very charming but merciless way, he makes fun of the idealists, and shows how their theories lead either to the ridiculous, or sometimes even do serious harm. He goes still further in saying that, even if the idealists at times offer something good and wholesome, this is simply borrowed from realism and presented under another name. As an example he gives some of the most beautiful Christian legends, and shows that Heaven itself is only a combination of elements taken from reality, combined by the imagination of man.

In speaking of Der Grüne Heinrich, it must be said that the book is not wholly a truthful narrative of the life of its author. To give only one example: Keller says nothing about the existence of his sister. Such omissions and other changes, although not strictly in accordance with reality, are admissible, since they give a literary and artistic form to the work; they take away nothing from the psychological truth, and it would be childish to contest the value of "Der Grüne Heinrich," to the philosopher, on account of these trifling alterations. On the contrary, thanks are due the author for not having detracted from the psychological value of the work by an accumulation of facts of no importance.

Keller's greatest peculiarity, which distinguishes him from most of his great predecessors, is, that he presents the biography of an entirely normal child. Goethe gives us the development of the childhood of a great genius, and moreover the title, "Poetry and Reality," indicates that the poet has added fiction to his narrative. With Rousseau and Marie Bashkirtseff we have the psychological conditions of two hyperæsthetic beings. But Der Grüne Heinrich is a boy scarcely different than his playmates. In spite of his intent for art and his love of nature, the reader realizes that he is not dealing with a child more intelligent or more sensitive than the average. It is for this reason, that the reader who cares little for fiction, and who takes special interest in no morbidness, will find Der Grüne Heinrich most congenial reading; he seems so near us because we understand him so well.

Not only is the character of the child in question absolutely normal, but also the conditions under which his childhood and youth are spent, are in no wise extraordinary. No attempt is made at a special system of education; it is the same to which most children of that time were subjected, and which we are now trying to reform. Again, no *one* particularly strong influence is apparent, which might in one way or another have influenced the spontaneous disposition of the child. It may be claimed that the loss of his father at the early age of five years is something out of the ordinary. Perhaps. But on the other hand it must be remembered that, in Europe, the authority of a father is very often of a despotic kind, and was still more so forty or fifty years ago. It consequently killed for most time the spontaneity of the child.

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Attention may here be called to the striking contrast with the autobiography of Stuart Mill, where we have an education which was entirely *sui generis* (tyrannical authority of his father), and brought about the most happy results.

In finally comparing Keller's autobiography with George Sand's, we shall find nothing but contrasts: home surroundings, character, primary instruction and education, all is as abnormal with George Sand as it is normal with Keller.

Keller's book may be divided into two parts; the first treats of his childhood and youth up to the age of eighteen years, the second tells us of the experiences of a young artist in a foreign country. Only the first part is of true pedagogical value. There we find the thoughts, the impressions, the emotions, the longings of a child, at home and out with his playmates, at his games and at school, all rendered with admirable fidelity and minuteness. (I should like to mention the description of the school founded according to the principles of Pestalozzi and Lancaster, Part I, Chapter XV.) One readily understands his deep resentment at the injustice done him, when those with whom he comes in contact judge him as though he were and adult, or according as they would judge children of a disposition different from his. We are present at the founding of the little friendships and hatreds of his early years; back of these we will always discover some utilitarian motive. On the whole, all is based upon little things: the most insignificant causes often result in the most complex effects which the child was unable to foresee and which often frighten him. He frequently acts without knowing why, sometimes in direct opposition with a very clear intention, and prompted simply by circumstances wholly accidental which appear at the fatal moment.

The development of the religious ideas of the child is given in a most interesting manner. Sometimes he thinks God must be like the weathercock on the church steeple, remaining lighted up when all the rest of the world is already in darkness; again he is like the terrible tiger in his picture book. Only gradually does he grasp the idea of a Heavenly Father, to which he is led by the manner in which his mother speaks of God. When left alone the child thinks very differently: God then is a Being of whom he thinks without cease; the fact that this remains without any result, annoys him, and he becomes disgusted and is even blasphemous. Sometimes, however, the idea of a Heavenly Father presents itself again; it is when he feels the *need* of help in the sad moments of his life, and in the hours of despair.[1] But the origin of the idea is wholly selfish, and it remains so even as he grows older, when the young catechumen has reasoned into nothing his religious instruction in its three parts treating of Sin, of Faith and of Love. Reason finds satisfaction only in the idea of the Spirit which embraces all, which animates all. "God seemed to me not spiritual, but a worldly spirit, because he is the world and the world is in him. God is radiant with worldliness." ("Gott Strahlt von Weltlichkeit.") God and nature are one to him. As for immortality, he has no faith in it; only on the day when the woman he loves dies, he *wants* to believe in it in order not to be forced to accept the thought of a separation forever.

Another psychological point which Gottfried Keller treats is the

[1] *Note.* The theories of the Theologians upon the origin of man's idea of God and the unclear conception of religious sentiment proposed by modern Ritschlianism in Germany, seem very small by the side of this luminous exposition by means of facts, of the formation of religious ideas in us.

two kinds of love which spring up in the child's heart, ideal and sensual, entirely independent of each other. Der Grüne Heinrich experiences two distinct kinds of love, one for a young, innocent and pure girl, the other, already aroused within the child in the guise of vague longing, is for a superb young woman some years older than he, the very personification of sensual although not impure love. The chapters treating of this are admirable. There are two personalities in the child, and Heinrich knows it and often thinks about it; it troubles him; the duality within him is repugnant to his *reason*; he should be but one, that would be more worthy of him. And this thought, of purely intellectual origin, constantly takes hold of him with greater force up to the day on which he loses the object of his chaste and ideal love. He determines to remain true to her only. But nature defies reason, and when he hears that the other woman he loves has left the town, it is a terrible blow to him. I know of no other example in the literature of any tongue, where the idea of such two simultaneous loves is so truthfully and successfully set forth, and with such perfect tact.

Keller offers no advice, no theories in his books. But he gives an ample harvest of minute and sagacious observations. It seem to me —but this is only a personal opinion—that, in looking upon the recent progress of the new pedagogy, "Child Study," as it is called, such precious contributions as the work of which I have been speaking, are too often overlooked or forgotten.

A. SCHINZ.

La Fatigue Intellectulle. Par A. BINET ET V. HENRI. Avec 90 figures et 3 planches hors texte. Paris, Librarie C. Reinwald. 1898. 336 pages.

This volume is the first of a series of books to be published in France: the *Bibliothèque de Pédagogie et de Psychologie*. We welcome this publication with great pleasure. Does it not mean that scholars abroad recognize the value of the researches first undertaken by American Pedagogues, and of which our Review, more than any other, is the special organ? Let me quote some lines from the Preface. It will be seen at once, that the end strived after in Europe, and especially in France, is a principle which has long ago been recognized by American students of pedagogy as the only fertile one. "The old pedagogy, in spite of many good details, must be given up entirely, because it is radically infected by error: it was constructed with artificial brilliancy (*chic*), it is the result of prejudiced ideas, it is without any real foundation, it substitutes literary quotations for strictly scientific demonstrations, it decides the most important problems by referring to authorities like Quintilian and Bossuet, it replaces facts by exhortations and sermons; the word which characterizes it best, is "Gabble" (*verbiage*). The new pedagogy must be based upon *observation* and *experience*. First of all it must be experimental. We do not mean here by experiment, vague impressions gained by persons who have seen much; an experimental work, in the scientific meaning of the word, is such, offering methodically collected documents, and, moreover, documents reported with sufficient precision and details as to make it possible to do the work of the author over again, to verify it, or to draw conclusions at which he did not arrive." (Pp. 1, 2.)

As a proof that the old methods are as pernicious as the authors claim, they give, in the first chapter, a report of the discussions held in 1886 and 1887, at the Academy of Medicine in Paris, in regard to the question of mental overwork (*Surmenage intellectual*).

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We must first of all define the term "Mental work." The book being a pedagogical work, the authors mean by mental work "all kinds of work done by pupils in school, either during recitations or during study hours." (P. 24.) The different kinds of work demanded of persons experimented upon, are: (1) mental arithmetic; (2) the recitation of a certain number of figures from memory; (3) reading. Other experiments, such as the recollection of some past occurrence, the exposition of a philosophical system, etc., are not considered wise, since they are too liable to bring in foreign elements, such as the searching for choice words, and so on. The book is divided into two parts:

Part I. Physiological Effects of Mental Work. I cannot make mention of all the results arrived at or reported by Binet and Henri. I shall confine myself to such as seem most striking to me. I pass over the experiments made by means of the Sphygmograph in order to establish the effect of mental activity upon the heart (the rapidity of pulsation, the rhythm, the propulsion strength of the blood). In the chapter on *capillar circulation*, the experiments made by Mosso and F. Franck are discussed at length. The results of the experiments made in the laboratory of Paris have been published previously in the *Année Psychologique* II and III.—The recent experiments of Patrizzi, referred to on pp. 82-3 must be noted here. They deal with the influence which the quantity of blood in the brain has on the rapidity of reaction. A boy with a gap in his skull served as a subject for Patrizzi to notice the time of amenia and hyperhemia of the brain; he gave the boy the sign to react while in the state of amenia, and again when in the condition of hyperhemia; and the result was, that the quantity of blood in the brain had much less influence on psychic phenomena than is often supposed.—The question of the relation between circulation in the brain and circulation in the body in general now presents itself. In his book on Fatigue Mosso states that there is a sort of antagonism, or inverse relation, between the two circulations. He abandons it in his more recent book on "The Temperature of the Brain," (1894). It seems to me that Binet and Henri are here and elsewhere rather severe on Mosso, whose book they call "a work of vulgarization." This is not wholly just. Binet himself admits that the theory of the antagonism, the first theory of Mosso, cannot as yet be considered as definitely refuted, and it is not impossible that this theory may reappear, varying but little from its original form. There is no reason why I should dwell upon this discussion; I wish to refer, however, to pp. 168, 284, 296, and to Chapter VIII in Part II, where we find very important facts which are far from contradicting the theory of inverse relations. On page 296, for example, we find the result obtained by Friedrich. A dictation was given to a class before it took its lesson in gymnastics; the number of mistakes made by the whole number of pupils was 62, while in a dictation given after a lesson in gymnastics, 152 mistakes were made, which is a greater number of mistakes than was noticed after an equal time devoted to mental work.—Nothing special is to be said as to the influence of mental work upon the circulation in the hand; nor of its influence on the blood pressure (Chapter III).—In the chapter on the temperature of the body in connection with mental work; (a) peripheric; (b) central, I only notice one result which seems certain; it is that the height of temperature during or after mental work is greater, sometimes by several degrees, in the left part of the brain than in the right (p. 135).—Chapter V deals with breathing. Here may be seen a very important practical result: the great difference in the amount of carbonic acid produced, according to the different kinds of work.

(See pp. 162-166.) The problem of the ventilation of school rooms should be based upon a precise knowledge of such difference. What a vast field of researches for people anxious to show that pedagogy is founded on psychology, and often on experimental psychology! One single and only very rudimentary experiment has been made so far. It is by Liebermeister, who obtained the following results: in ½ hour of quiet repose, a physician 42 years of age exhaled 15.6 gr. of carbonic acid; in ½ hour of singing, 20.8 gr.; while reading, 18.7 gr.; while sleeping, 12.3 gr.

In Chapter VI we see the effects of mental work on the muscular strength. This, as well as all the preceding chapters, is a very good summary of researches made up to the present day. Among others, the authors summarize the experiments made by Heinrich and Mentz on the diameter of the pupil of the eye, and of Heinrich on the crystalline of the eye. The pupil expands as a result of mental work, or when the eye is used in indirect vision; and the radius of the curve of the crystalline grows larger in indirect vision, or as a result of mental work. The researches of Mr. Dougall (Psychological Review, March, 1896), on the relaxation of the fingers during mental circulation, are also alluded to. The instruments used are, among others, the Dynamometer and Ergograph. I call attention to a long criticism of Mosso's Ergograph (pp. 178-189),[1] which the authors, however, admit to be a useful instrument (p. 184). Finally, a very interesting discussion of the hypothesis of Kraepelin and Koch, that the height of the lifting with the ergograph depends upon the condition of the muscles, but the number depends upon the central neural system (p. 187 ss.).

Chapter VII. On Nutrition. Here, again, the experiments made so far are few in number; and yet it would be very useful to know more about this special subject. One result seems positive, namely, that the amount of food consumed by a person diminishes when he does mental work. In the Normal School of Mirecourt (France), the boys consume, on an average, 750 gr. of bread per day, girls 550. At the end of the school year, boys consume about 200 gr. less, and girls 100. It is very probable that this diminution is due to school work, since the statistics on the alimentation of imprisoned women, also show variation, though not regularly between the month of October of one year to July of the next.[2]

Part II. Psychological Effects of Mental Work. A. Laboratory Researches. Almost all of those given, have been made by Kraepelin. The six kinds of experiments made are: 1. the counting of letters in a text printed in Latin characters; 2. addition of numbers of one figure; 3. writing of dictations; 4. reading aloud; 5. recollecting a series of figures; 9. recollecting syllables. There are two main factors to be considered: *exercise* and *fatigue*. According to Oehrn, the collaborator of Kraepelin, the first factor increases the rapidity of work, the second diminishes it. One or the other predominates—at first exercise is stronger, later on fatigue. The difference in individuals as well as the difference according to the kind of work, are the object of numerous experiments referred to by Binet and Henri. Our authors give a method which renders the comparison of the different results possible (pp. 252-8).—In Chapter II the subject is continued, and we see the factor of exercise acting after very long periods of rest or intermission. Oehrn claims that, only after 47 and 72 hours of intermission, he found a loss of influence of the acquired exercise upon mental work (p. 264).—Chapter IV is devoted to the report and examination of Bettmann's experiments on the time of reaction, on the rapidity

[1] For more details see "*Année Psychologique*," IV year, 1898. Pp. 253-267 and 303-316.
[2] For more details see "*Année Psychologique*," IV year, 1898. Pp. 337-356.

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with which additions were made, and the memory of figures; *a.* without preceding periods of work; *b.* after physical exercise; *c.* after mental work.

B. School Researches. Chapter V: Method of Dictation (especially Friedrich). Chapter VI: Methods of Calculation (especially Bergerstein). Chapter VII: Method of recollecting figures, and method of combination. These methods were used by Ebbinghaus in the experiments which the Mayor of Breslau ordered to be made in 1895. Psychologists have already said much about these inquiries. I therefore need only to state that Binet and Henri offer a thorough criticism of the whole work directed by Ebbinghaus.

Finally, in Chapter VIII, we have the "Method of Tactile Sensitiveness." The determination of the feeling of the distance of prickings before and after mental work, on different parts of the skin.

In the last chapter the authors fully recognize that there are but few practical conclusions that can be drawn from the experiments made up to the present time. This is the reason why the different topics treated have been taken up again. It seems to me that the authors succeeded very well in doing the pioneer work which they had proposed themselves. For in each chapter of this valuable study on fatigue, one can find the clearest and most suggestive exposition of the question such as it presents itself at the present moment. I should dwell longer upon the skill of the authors of advantageously treating the scarce material at their disposition, of combining the results, and of suggesting new experiments; but this is unnecessary, since their reputation has been established long ago among psychologists.

I should like now to remind the reader of the advice Binet and Henri give, and which ought to be remembered in every study upon this subject. "Fatigue brought about by a lesson, is a natural effect; it must come if the pupils have been attentive, since every effort is accompanied by a certain amount of fatigue. . . . . One might even make the paradoxical statement, that it is only in fatiguing ourselves, that we can develop ourselves physically as well as intellectually. It is over-fatigue which does harm, not natural fatigue; a good book might be written, entitled: "The Necessity of Fatigue for Physical and Intellectual Hygiene." (Pp. 302-3.)

ALBERT SCHINZ.

Work and Play in Girls' Schools, by DOROTHY BEALE, and Others. London, 1898. pp. 433.

The Principal of Cheltenham, H. M. Soulsby and Jane F. Dove, also head mistresses, have here gathered, edited, and prefaced some two score of brief papers, grouped in four parts—humanities, mathematics, science and æsthetics,—with a brief concluding paper on moral and physical education. The many writers seem to be all practical teachers of girls with high ideals, and the papers altogether constitute one of the sanest and most comprehensive presentations of the ways and means of educating maturing girls, we have. All interested in the subject should read and ponder its contents.

The Gods of Our Fathers, by HERMAN I. STERN. Harper & Bros., New York, 1898. pp. 269.

This is a study of Saxon mythology, which digests and sets forth in very presentable style the legends of the formation of the world, the gods and their abode, Queen of Asgard, Loki and his brood, giants and dwarfs, Thor's adventures, the golden age of the gods, Balder's death, the twilight of the gods. It is a work that every student and teacher of mythology should possess.